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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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And Auxiliary Machinery as supplied to the Admiralty. 2179

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BIRMINGHAM. 1241
See Advertisement last week, page 80.

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PATENT 1293
BOILERS *See Page 82.*
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See page 17. 1134

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Gas Engines Inspected, Tested and reported upon. Over 25 years' experience. Tel.: 36 and 737 Stratford. Wire: "Rapidising, London."
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Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817
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HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement, page 69, May 25.

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SHALLOW DRAFT VESSELS. 818

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Worm Wheels cut up to 13 ft. diam.
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Systems
PRESSURE, AIR, STEAM
For Boilers of all types.
KERMODES LIMITED,
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Naval Outfits a Speciality, also for Merchant Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds.
Supplied to the British and other Governments.
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Locomotives Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
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See their Illus. Advertisement, page 85, last week.
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and
INDUSTRIAL PROPERTIES. 9866
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Undertake SPECIAL MACHINE WORK of any description.
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GENERAL CONSTRUCTIONAL ENGINEERS,
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Tubes AND Fittings
AND
Steel Plates.
Stewarts and Lloyds, Ltd.
GLASGOW - BIRMINGHAM - LONDON.
See Advertisement Page 98. 1111

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PETERBOROUGH.
STEAM ENGINES AND TURBINES.
GAS AND OIL ENGINES.
AIR COMPRESSORS.
REFRIGERATING PLANT. 1475
See Advertisement, page 49, May 25.

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Including Machine Moulded GEAR WHEELS up to 10 feet dia.;
FLY WHEELS (rope or spur drive) up to 28 feet dia.;
IRON CASTINGS up to 15 tons each, in Loam, Dry or Green Sand;
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The Strongest Chain in the World.
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Forgings, Castings, Bars, Sheets, Wire, Tubes.
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Telephone: Central 7424. Od 585

Phone—Holb. 541. Tele.—Andrubo, Holb., London.
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D.B.S. GEARS
of every description. 1440

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Engines. 1120
CARELS DIESEL & STEAM ENGINES (LONDON), LTD., Carlton House, Regent Street, London, S.W. 1. Telephone: Regent 2484.

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FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, } ROWE'S PATENTS.
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SYPHONIA STEAM TRAPS, REDUCING VALVES
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LAND AND MARINE
YARROW BOILERS. 819

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LEVENFORD WORKS, Dumbarton. 1483
See Full Page Advt., page 59, May 25.

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Walter Somers, Limited,
HALESOWEN. 7116

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For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
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See advert., page 93, May 25. 8196

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Crossings.
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DARLINGTON. 1319

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Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS, PRESSED STEEL WORK OF ALL KINDS.
Registered Office and Chief Works: Motherwell.
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THOMAS HUNT & SONS,
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Est. 1854. 1313

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Makers of
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Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c., &c. 846

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 939
See half-page Advertisement, page 65, May 11.

The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by Sir WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 1311

PATENTS AND DESIGNS ACTS, 1907 and 1919.

Notice is Hereby Given that

Charles Day, of Mirrlees, Bickerton & Day, Limited, Hazel Grove, near Stockport, in the County of Chester, seeks leave to amend the specification of Letters Patent No. 192971 entitled "Improvements in fuel valves for internal combustion engines."

Particulars of the proposed amendment were set forth in the Illustrated Official Journal (Patents) issued on the 24th May, 1923:

Any person, or persons, may give notice of Opposition to the Amendment by leaving Patents Form No. 19 at the Patent Office, 25, Southampton Buildings, London, W.C.2, within one calendar month from the date of the said Journal.

W. TEMPLE FRANKS,
Comptroller-General. A 686

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), and ALL ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 56, SOUTH JOHN STREET, LIVERPOOL. 1296

TENDERS.

COUNTY BOROUGH OF PORTSMOUTH.
ALTERATION OF TIMB.

Tenders are Invited for :—

(A) The REMOVAL of a 60 ft. HLECTRICALLY OPERATED BASCULE BRIDGE: and/or
(B) The PURCHASE and REMOVAL of same.

For further particulars and illustration of Bridge, see page 9. A 626

Town Hall, Portsmouth. F. J. SPARKS,
17th May, 1923. Town Clerk.

STEEL RAILS.

Sealed Tenders will be

received by the Director of Army Contracts until Eleven a.m. on the 7th June, 1923, for the PURCHASE of SECOND HAND FLAT BOTTOMED STEEL RAILS as follows:—

245 cwts. of Rail weighing 45 lbs. per yard in 30 ft. lengths.

73 cwts. of Rail weighing 105 lbs. per yard in various lengths from 6 ft. to 23 ft.

Forms of Tender, Conditions of Contract and any further particulars may be obtained on application to the DIRECTOR OF ARMY CONTRACTS (D.C. 7), Imperial House, Tothill Street, Westminster, S.W.1. A 646

COUNTY OF LONDON.

The London County Council invites

Tenders for a Fuel Economiser

having 360 tubes, for Abbey Mills Pumping Station, Abbey Lane, Stratford, E.15.

Persons desiring to submit Tenders may obtain on and after Monday, 4th June, 1923, the Drawing, Specification, Form of Tender, etc., on application to the Chief Engineer at the Old County Hall, Spring Gardens, S.W.1, upon payment of the sum of £2. This amount will be returnable only if the tenderer shall have sent in a *bona fide* Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the Drawing, Specification and other contract documents may be inspected at the Old County Hall before payment of the fee.

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E.1, after Four p.m. on Monday, 18th June, 1923, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council.
A 632

ABERDEEN CORPORATION WATER WORKS.

EXTENSIONS 1920.

CONTRACT No. 10—NEW AQUEDUCT.

The Town Council of Aberdeen are prepared to receive

Tenders from Competent

Persons willing to enter into a Contract for the MANUFACTURE and DELIVERY of about 3 miles of 4 feet diameter PIPES and SPECIALS of the following alternative types, viz:—

(A) Cast Iron.
(B) Mild Steel (Lapwelded).

The Drawings may be inspected and Specification, Schedule of Quantities and Form of Tender obtained, on and after 30th May, 1923, on application at the Water Engineer's Office, 41½, Union Street, Aberdeen. Early application is desirable and no Specification will be given out after 8th June.

For each Specification of each type a deposit of Five Pounds sterling will be required, which sum will, after a Tender has been accepted, be returned to the tenderer, provided that he shall have sent in a *bona fide* Tender, based on the Drawings, Specification and Schedule of Quantities provided, with the Schedule of Quantities fully priced out in detail, and shall not have withdrawn the same.

Tenders on the Forms prescribed and enclosed in securely sealed envelopes, endorsed "Tender for New Aqueduct Piping" are to be addressed to the undersigned. No Tender delivered after Five p.m. on the 22nd June, 1923, will be considered.

The Town Council do not bind themselves to accept the lowest or any Tender.

No person should Tender unless thoroughly experienced in the actual construction of extensive public works.

GEORGE MITCHELL, M.Inst.C.E., F.G.S.,
Water Engineer.

Water Engineer's Office,
41½, Union Street, Aberdeen.
21st May, 1923. A 611

ADMINISTRATIVE COUNTY OF LONDON.

RECONSTRUCTION AND WIDENING OF WICK LANE BRIDGE, HACKNEY.

The London County Council invites

Tenders for the Reconstruction

and WIDENING of WICK LANE BRIDGE over the Hackney Cut in the Metropolitan Borough of Hackney.

Persons desiring to submit Tenders may obtain the Form of Tender, etc., on application to the Chief Engineer at The Old County Hall, Spring Gardens, S.W. 1 upon payment of the sum of £3 This amount will be returnable only if the tenderer shall have sent in a *bona fide* Tender, and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the contract documents may be inspected before the payment of the fee.

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, after Four p.m. on Monday, 18th June, 1923, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council. A673

PORT OF BRISTOL.

NEW ELECTRIC CRANES, BRISTOL DOCKS.

The Docks Committee are prepared to receive

Tenders for the Construction

of TWO 3-ton MOVABLE, ELECTRIC, JIB CRANES, and the ERECTION of the SAME on the Roofs of Sheds "Y" and "Z," Canon's Marsh, Bristol Docks.

On and after Thursday, the 31st day of May, 1923, copies of the General Conditions, Specification, Schedule of Prices, and Contract Drawing can be obtained from the undersigned on production of a receipt shewing that a deposit of £3 has been paid to the Bristol Docks Committee, 19, Queen Square, Bristol, to whom all cheques must be made payable. The deposit of £3 will be returned hereafter to all *bona fide* Tenderers.

Tenders must be enclosed in a sealed envelope endorsed "Tender for Two Electric Cranes" and addressed to the General Manager and Secretary of the Docks Committee, 19, Queen Square, Bristol, and must be delivered to him accompanied by all the prescribed documents and drawings before ten a.m. on Monday, the 2nd July, 1923.

The Docks Committee do not bind themselves to accept the lowest or any Tender.

THOMAS A. PEACE,
Engineer.
Port of Bristol.

Chief Engineer's Office,
Avonmouth Docks,
23rd May, 1923. A 646

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby

invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification will be available upon application to :—

AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C. 2.

SPECIFICATION No. 23/77.
ALUMINIUM STEEL CORED CABLE
0.0707 SQ. IN.

CHARGE :—£2 for the first three copies of Tender Form, Conditions of Contract, Specification complete. These charges will be returned on receipt of a *bona fide* Tender. A fourth copy and any further copies will be supplied for the sum of 10s. each.

PRELIMINARY DEPOSIT :- A preliminary deposit of £100 is to be lodged with the Tender.

The Specification may be inspected at the abovementioned office.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne not later than Five p.m., 31st August, 1923.

R. LIDDELOW,
Secretary,
State Electricity Commission of Victoria,
Melbourne, Victoria,
Australia. A 629

ABERDEEN CORPORATION WATER WORKS.

EXTENSIONS 1920.

CONTRACT No. 11.—NEW AQUEDUCT.

The Town Council of Aberdeen are prepared to receive

Tenders from Competent

Persons willing to enter into a Contract for the TRANSPORTING, LAYING and JOINTING of about Three Miles of 4-ft. PIPING, and ANCILLARY WORKS between CULTER and WEST CULTS.

The Drawings may be inspected, and Specification, Schedule of Quantities, and Form of Tender obtained, on and after 30th May, 1923, on application at the Water Engineer's Office, 41½, Union Street, Aberdeen. Early application is desirable, and no Specification will be given out after 8th June.

For each Specification a deposit of Five Pounds Sterling will be required, which sum will, after a Tender has been accepted, be returned to the Tenderer, provided that he shall have sent in a *bona fide* Tender, based on the Drawings, Specification and Schedule of Quantities provided, with the Schedule of Quantities fully priced out in detail, and shall not have withdrawn the same.

Tenders, on the Forms prescribed, and enclosed in securely sealed envelopes, endorsed "Tender for Aqueduct Pipelaying," are to be addressed to the undersigned. No Tender delivered after Five p.m. on 22nd June, 1923, will be considered.

The Town Council do not bind themselves to accept the lowest or any Tender.

No person should Tender unless thoroughly experienced in the actual construction of extensive public works.

GEORGE MITCHELL, M.Inst.C.E., F.G.S.,
Water Engineer.

Water Engineer's Office,
41½, Union Street, Aberdeen.
21st May, 1923. A 612

BOROUGH OF LANCASTER.

ELECTRICITY DEPARTMENT.

For Sale.

Two 200 kilowatt direct coupled Bellias-Westinghouse direct current GENERATING SETS, 460-520 volts with field regulator. Slip rings fitted for static balancer for three-wire working.

One 300 kilowatt direct coupled Bellis-Westinghouse direct current GENERATING SETS 460-520 volts with field regulator.

Each set is complete with Korting Ejector Condenser.

Plant can be seen running up to 9th June, 1923. Plant is for immediate disposal and removal.

Full particulars can be obtained from the undersigned to whom Tenders should be submitted by 9th June, 1923.

The highest or any Tender will not necessarily be accepted.

GEO. C. MILNES,
Electricity Works,
Marton Street,
Lancaster. A 685

THE METROPOLITAN ASYLUMS BOARD invite

Tenders for Covering Steam

BOILERS, STHAM and HOT WATER PIPES, Etc., WITH NON-CONDUCTING COMPOSITION AT LONG REACH SMALLPOX HOSPITAL, DARTFORD, KENT, in accordance with Drawings and Specification prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Drawings, Specification, and Form of Tender may be Inspected at the Office of the Board, Victoria Embankment, E.C.4, on and after Ten a.m. on Saturday, 2nd June, 1923, and can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of a *bona-fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification and the Drawings have been returned.

Tenders addressed as noted on the form must be delivered at the Office of the Board not later than 2.30 p.m. on Wednesday, 20th June, 1923.

(By Order)
G. A. POWELL,
Clerk to the Board.
1st June, 1923. A 690

THE BENGAL AND NORTH-WESTERN RAILWAY COMPANY, LIMITED,
and
THE ROHILKUND AND KUMAON RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the Supply of :—

(A) RAW MATERIAL for 470 G.G. Wagons and 10 Timber Trucks,
(B) 1120 prs. WHEELS and AXLES for Carriages and Wagons,
(C) 1960 AXLE BOXES for Wagons,
(D) 1960 VOLUTE SPRINGS for Wagons,
(E) 1960 LAMINATED SPRINGS for Wagons,

as per Specifications to be seen at the Company's Offices.

Tenders addressed to the undersigned, and marked "Tender for Wagons," or as the case may be, are to be lodged not later than Noon, on Friday, the 29th day of June, 1923.

For Specifications (A) and (B) a fee of £1 each, and (C), (D), and (E), 10s. each will be charged, which cannot, under any circumstances, be returned.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
E. A. NEVILLE,
Managing Director.

237, Gresham House,
Old Broad Street,
London, E.C.2.
30th May, 1923. A 713

GREAT NORTHERN RAILWAY (IRELAND).

TO BRIDGE CONTRACTORS.

The Directors are prepared to receive

Tenders for Reconstruction of

BRIDGE No. 20 BETWEEN HOWTH JUNCTION AND PORTMARNOCK,
and
REPAIRS TO GIRDERWORK OF BRIDGE No. 134 BETWEEN CASTLEBELLINGHAM AND DUNDALK.

The Drawings and Specification may be inspected at the Engineer's Offices, Dublin and Belfast, and copies of same, together with Form of Tender, may be obtained from the undersigned on payment of One Guinea, which will be refunded on receipt of a *bona fide* Tender and return of the Drawings.

Tenders made out on the Forms supplied by the Company should be delivered under sealed cover, endorsed "Tender for Bridgework," not later than Ten a.m. on Thursday, 21st June, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

J. B. STEPHENS,
Secretary.

Amiens Street Station, Dublin.
30th May, 1923. A 707

APPOINTMENTS OPEN.

THE UNIVERSITY OF SHEFFIELD.

PROFESSORSHIP OF MECHANICAL ENGINEERING.

The Council of the University invite

Applications for the above

POSITION, shortly to become vacant.

Applications should be received by the undersigned, from whom further particulars may be obtained, by the 12th June.

W. M. GIBBONS, Registrar. A 580

Wanted, Assistant Manager,

by well-known Gear Makers. Must have good all-round knowledge of machine-cut gearing, and previously held similar position. Age about 35 years.—Address, A 640, Offices of ENGINEERING.

Lifts.—Estimator Required

for well-known firm of Lift Engineers. Must be experienced and capable. State full particulars.—Address, A 694, Offices of ENGINEERING.

Mechanical Engineer.—

WANTED, for Oil Refinery in the East, an ENGINEER with sound mechanical training and experience, and with some knowledge of constructional work. Three years agreement in first instance, with good prospects for permanent senior position. Age 30 to 35.—Apply, with particulars of experience, to BOX G., c/o REGENT Advertising Service, Ltd., 4, London Wall Buildings, London, E.C.2. A 709

Engineer Required to take

charge of oxygen plant, also small machine shop and supervise men. One with previous experience preferred.—Write giving full particulars, references, and salary required to BOX 2882, WILLINGS, 30, King Street, Covent Garden, W.C.2. A 709

A Large Electrical Firm has

a VACANCY for a thoroughly experienced TEST BED ASSISTANT as right hand man to Chief. Experienced in all classes of electrical machinery, including Turbo Alternators and Rotaries essential.

Replies will be treated in confidence and should include age, experience and salary required.—Address, A 701, Offices of ENGINEERING.

Electrical Assistant Required

for Engineering Department of large Industrial Company. Technical Training and a few years practical experience with A.C. and D.C., Factory or Mining Plants essential. Some knowledge of Fuel Technology and Gas Analysis desirable. Original testimonials should not be sent. Apply by letter giving full particulars of training and experience, and stating age and salary required.—Address, A 674, Offices of ENGINEERING.

Constructional Steel Work—

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REQUIRED for the Public Works Department of the Government of the Straits Settlements for three years' service with prospects of permanency. Salary $400 a month rising to $800 a month by annual increments of $25 a month, plus a temporary non-pensionable allowance of 10 per cent. The exchange value of the dollar in sterling is at present fixed by the Government at 2s. 4d., and its purchasing power in Malaya is considerably less than that in the United Kingdom. Free passages provided. Candidates aged 25 to 35, unmarried, must be Associate Members of the Institution of Civil Engineers, and have passed the full examination of the Institute of Municipal and County Engineers, and have had at least three years' practical experience (exclusive of pupilage) as Engineering Assistants under an Engineer who is a Member of the Institution of Civil Engineers. —Apply at once by letter giving brief details of qualifications and experience to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W.1, quoting M/11956. A 697

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The Directors are prepared to receive

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Candidates should be about 24 years of age and single, and must have received a good general and technical education, with experience in electrical engineering on a large railway system, or in workshops or power plant. Candidates should give details of their practical experience.

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TERMS: A three years' agreement in the first instance, and first-class free passage to India and home again on termination of service.

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S. G. S. YOUNG,
Secretary.

Offices: 91, Petty France, Westminster, S.W.1.
26th May, 1923. A 677

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ALTERNATING MAGNETISM.

WHEN Mr. W. M. Mordey discoursed on "Recent Studies of Alternating Megnetism" at the Royal Institution on May 18, his chief difficulty was to make the phenomena—fascinating to the individual observer—visible and clear to the large audience. Our difficulty will be similar. Even the kinematograph could hardly give an adequate idea of the peculiar haste with which finely-divided particles of certain materials, magnetic or unmagnetic in the ordinary sense, seem to make their escape from alternating-current magnetic fields, whilst continuous current fields would keep them bound in closed circuits. Yet at first sight the A.C. magnetic phenomena differ little from the D.C. phenomena. That was the first point which Mr. Mordey demonstrated. He held an ordinary solenoid magnet over filings or fine grains of magnetic materials; iron, nickel, Heusler alloy (copper-manganese-aluminium), magnetite Fe_3O_4, &c., all adhered to the pole, cobalt less strongly than the others, the grey specular hematite Fe_2O_3 scarcely at all—a technically regrettable fact, Mr. Mordey remarked, since it prevents the magnetic concentration of this ore.

When a similar magnet was excited by alternating currents, the attractions were less strong, but the phenomena were similar, and the linking of the particles in lines of force was quite distinct in some cases. Fig. 1 shows the attraction of magnetite by a single A.C. pole, Fig. 2 that of cobalt filings by an A.C. horseshoe magnet. When Mr. Mordey applied the A.C. pole to specular hematite he noticed a slight repulsion, and that induced him to study alternating magnetism.

The effects of A.C. magnetism on this hematite is illustrated in Fig. 3. Hardly any particles adhere to the pole, but they are driven out of the field, surrounding the pole like a halo; the hematite is supposed to be paramagnetic, about $\frac{2}{10}$ as strong as iron. With a two-pole A.C. horseshoe magnet, the particles arranged themselves as in Fig. 4, the two halos coalescing to an equatorial belt, suggestive of diamagnetism; there is no indication of lines of force, and the phenomena are not analogous to the concentric lines of force surrounding a wire through which a direct current is flowing. But Mr. Mordey succeeded in obtaining a perfectly distinct, though faint, indication of an equatorial grouping of the hematite also with a powerful D.C. horseshoe magnet; he therefore considers specular hematite as diamagnetic and ascribes the non-observation of this feature to the fact that the specular hematite is generally impure and contains traces of magnetite. The effect produced under similar conditions, *i.e.*, with single-phase currents on Heusler alloy is shown in Fig. 5. The material does not adhere to the poles, but there are distinct lines of force between the poles and further equatorial groupings.

For the further demonstrations with the two-phase currents of the electricity supply (at 83 periods per second) Mr. Mordey had arranged eight poles in a row, poles 1, 3, 5, 7 being wound with coils connected to the first phase and poles 2, 4, 6, 8 with the second phase; the two phases were switched in either separately or simultaneously. With separate excitation an inactive pole would be between two excited poles. All the cores were laminated, the laminations being parallel to the longitudinal axis of the row of poles, which might be said to form a rectangular field with rounded corners. The cores of the previously-mentioned A.C. magnets had also been laminated and, as in their case, pieces of paper or slabs or trays of glass were put on the pole faces to prevent the magnetic particles from sticking directly to the poles.

Using such an arrangement with twelve poles, of which six only were excited (one phase), Mr. Mordey obtained, with specular hematite, the photographs which are reproduced in Fig. 6. These showed that there was strong repulsion, and a new feature became apparent. In the upper photograph the vertical distance gap between the pole faces and the materials was $\frac{5}{8}$ in., in the lower the gap it was $\frac{1}{4}$ in.; in the lower photograph more material was used, but the phenomena clearly changed with the width of the gap (of air and glass) intervening between the pole face and the material. In order to elucidate these features, Mr. Mordey threw a curve on the screen in which the pull of a D.C. magnet was plotted against this vertical distance between the pole and the material it acted on. The maximum pull, quite close to the pole face, was 5 lb. in this case; within $\frac{1}{4}$ in. the pull dropped down to less than $\frac{1}{2}$ lb. The curve, Fig. 7, obtained with an A.C. magnet, was entirely different. The ordinate of Fig. 7 is the reciprocal of the time in seconds, *i.e.*, the speed at which the alternating current repelled the particles; the abscissa marks the air gap in inches. At a distance of $\frac{1}{64}$ in. from the pole face there was no movement of the particles at all; at $\frac{1}{32}$ in. the speed was 1·5, at $\frac{1}{4}$ in. the speed was 4; then the speed fell off again, but at

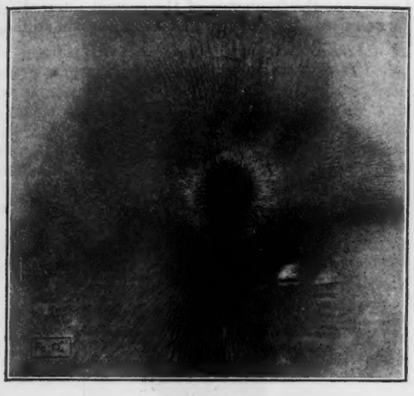


FIG. 1.

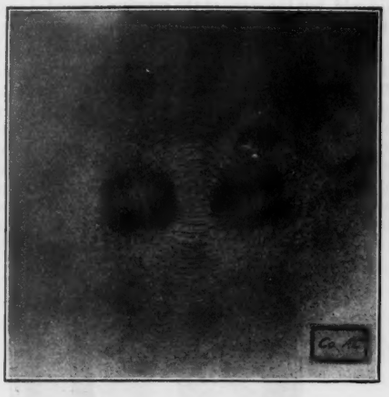
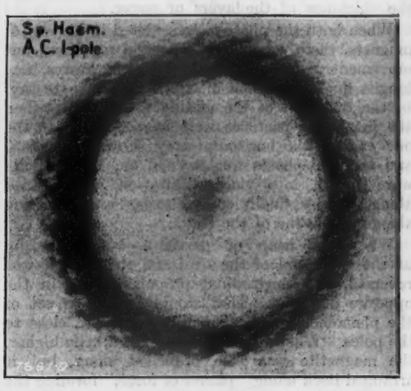


FIG. 2.



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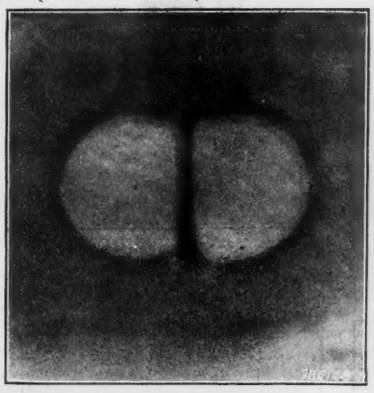

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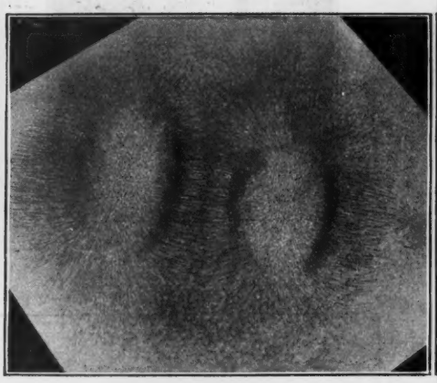

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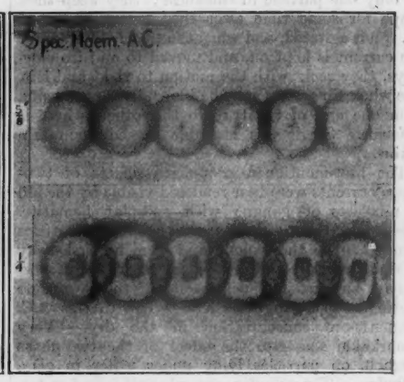
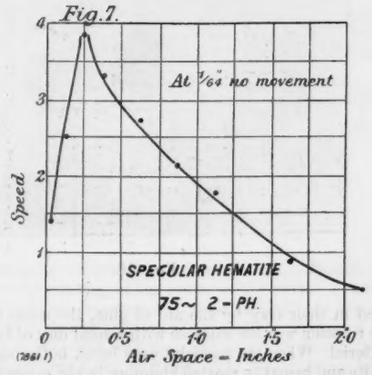


FIG. 6.



a much slower rate than with direct currents. This curve was obtained by putting the hematite experimented with into a photographic tray slightly bulging downward at the one end, so that the material was very close to the pole; the tray was then gradually lifted and the time occupied in driving the material away was observed. In confirmation of this observation Mr. Mordey found that when he used the thinnest sheet of paper obtainable as table for his material, there was no movement at all, and when several sheets were placed on the poles, the phenomena changed with the thickness of the layers of paper.

When both the phases were excited in his row of magnets, there was not only general repulsion, but movement upward, sideways and lengthways, *i.e.*, longitudinal propulsion of the material, so to say, in the direction of the gliding field. Thus when the magnetite particles were heaped up near the one end of the horizontal tray shown in Fig. 8, and the two phases were turned on, the particles were thrown into violent agitation, and hurried along the tray, finally coming to rest and collecting along the outline of the field.

When the heap of particles was piled up at the other end of the tray and the current was reversed, the longitudinal propulsion was in the opposite direction. That would be the aspect of the phenomena with a small air gap, *i.e.*, close to the poles. When the tray was lifted a little higher, the magnetite was also propelled along, but it arranged itself along "planes of force," forming the "fins" which Fig. 9 shows; the material of Fig. 9 is fine nickel filings. These fins are very curious; they have considerable rigidity, though they may be only one particle in thickness; they keep their shape for some time after the current is turned off, if not agitated, and when the tray is lifted while the current is kept on, and moved to and fro sideways, they rock with the motion to right and left. The whole fin system may be blown by the currents, from one end of the tray to the other, where it re-forms. Single fins resemble jagged mountain chains.

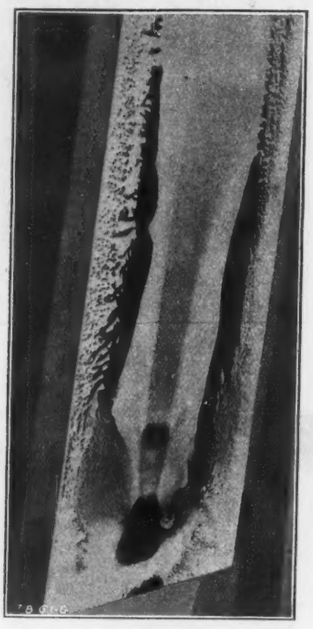
The first-mentioned propulsion effects of two-phase currents were best rendered visible by the aid of mixtures of gangue with specular hematite. One could then see how the hematite particles climbed up in the gangue and were hurried away to right and left and onward, at great speed, possibly a hundred feet per second, if there were no friction. The gangue is left at rest in this A.C. magnetic-ore concentration in the dry. Very remarkable was also the effect of the two-phase magnets on particles lying under water in glass cylinders. The cylinder was only half full of water, and when it was laid on the glass slab, at angles up to 15 degrees, no water would flow out of the open top of the cylinder. As soon as the current was turned on, however, the mud or slime of particles of metal or ore, though not stirred, was violently agitated, and the particles rose and dragging water with them flowed out of the cylinder, thus being concentrated in the wet; the gangue was again left behind. These ore concentrations were demonstrated with various materials, comprising also tinstone and gangue, and mixtures of tinstone and tungsten; in the latter case the tungsten travelled more rapidly than the tinstone. Several samples of the magnetite we have spoken of were the highly titaniferous black sand from New Zealand.

Our last two illustrations concern the effects of one-phase currents on ores which this examination would prove to be mixtures if that fact were not recognised. In Fig. 10 we see sulphidic nickel ore from Sudbury, Ontario; some particles are heaped upon the pole but there is also a halo. Fig. 11 shows a mixture of the magnetic iron oxide Fe_3O_4 and of specular hematite Fe_2O_3, and it should be compared with Fig. 1. which illustrates the effect of the same current on pure magnetite, and with Fig. 3. in which we perceive the halo due to the hematite.

Mr. Mordey had little time to discuss the theory of his very complex phenomena. Eddy currents might be thought of in the first instance. But eddy currents require bodies of somewhat considerable dimensions for their proper developments, and if eddy currents were a chief factor, powdered aluminium should behave like these more or less magnetic materials; yet the A.C. magnets had no effect whatever on powdered aluminium. When a solid disc of aluminium (or copper, &c.) provided with a spindle about which it could rotate, was held horizontally half way across one of the poles, it began to spin, of course; but the direction of the rotation was the opposite to that in which the particles were propelled along the axis of these fields. Replacing the metal disc by a cylindrical tray, filled with his various materials, Mr. Mordey showed that powdered aluminium gave no spin. The magnetic powders did spin, but the sense of the rotation depended upon their physical conditions. When the particles were fixed in their tray by the aid of glue, the sense of the rotation was the same as with a solid disc of the material. When the particles were loose, both magnetite and hematite started spinning in the opposite sense, and it would appear that the loose particles were rotating about some axis while being propelled by the alternating-current magnetic field. The effect of the distance between the pole and the particles may be connected with the leakage from one pole over to another. That leakage would be along fairly horizontal lines close to the polar surfaces, but the leakage lines, from poles adjacent or more remote, would cross one another at higher levels.

Without wishing to question that some force at present not understood may act in his phenomena, Mr. Mordey considered that magnetic hysteresis was concerned in them. The relative intensities of the forces acting in different directions evidently changed with conditions. Mere diamagnetism would be too weak to account for the effects observed. That hysteresis came in was indicated by the fact that cast-iron, of a high hysteresis constant, showed great translational movement, whilst materials of low hysteresis like silicon iron (stalloy, which Mr. Mordey had used in several of his demonstrations) and nickel were strongly repelled upward, so as to stand up in fins, but little propelled along the longitudinal axis. As the frequency of the current alternations was raised, the vertical repulsion and fin stiffness increased, but the translation effect became weaker. With increased field intensity the distances the adjacent planes of forces increased, and the fins were more widely spaced. We should mention that some of the effects were fixed by means of applying a coating of wax to the paper or glass, serving as table, and subsequently melting the wax.

Mr. Mordey gave the first account of these interesting experiments last year at the Royal Society Soirée*. He has since continued his researches at the Imperial College of Science with the assistance of Mr. A. Rushton, who also assisted in the demonstrations on the 18th inst. Mr. Mordey did not



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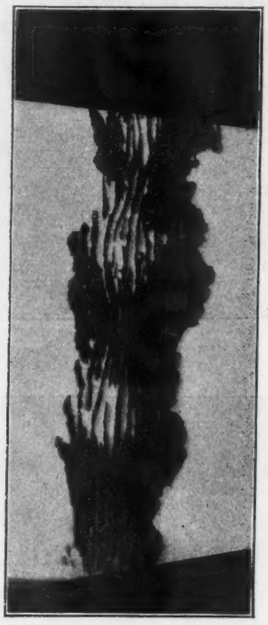


FIG. 9.

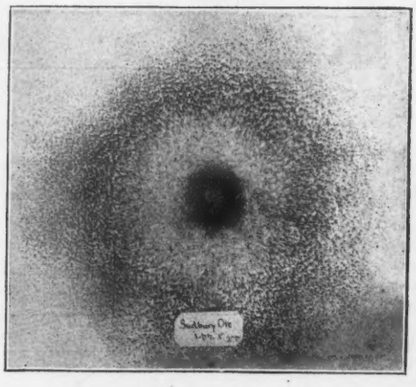


FIG. 10.

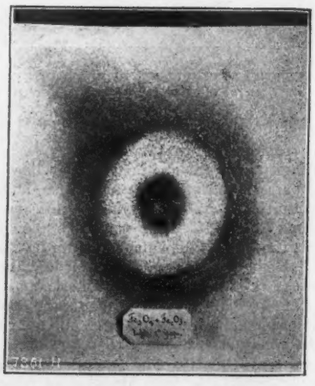


FIG. 11.

* See ENGINEERING, May 19, 1922, page 629.

refer to practical applications. But it is to be hoped that this promising line of research will not be overlooked, and that Mr. Mordey will persevere in his investigations.

MULTI-CUTTING TOOL ARRANGEMENTS.

By JOSEPH HORNER.

(*Continued from page* 485.)

Milling Cutters.—Leaving now the groups of singte-edged tools for those with many edges, the movement towards multiplication of units is apparent. Many milling cutters consist simply of a number of single-edged tools arranged in a circle in a head, or around a cylindrical body, as illustrated by the inserted-tooth cutters, the designs of which are numerous. There are two aspects, therefore, which this subject wears, that of the efficiency of the cutting points, and edges, and the association of units in gangs, and the operation of several cutters on different parts of a single piece.

The Efficiency of Cutters.—The very marked differences that exist in the shapes of the teeth of these cutters, and in their performances can only be explained by their evolutionary growth. All the early mills had teeth of weak, slim section, and finely pitched. Now the opposite extreme is often adopted, which however, if carried too far, does not make for efficiency. Early cutters were only used for fine finishing, but now large groups are designed for roughing. The action of face or end mills is different from that of edge mills. That of single-edged cutting tools is only closely paralleled by that of face mills with inserted cutters.

The efficient action of cutters is often seriously reduced by lack of rigidity in the machines on which they are used, or in that of the arbors. The result is chatter, and a roughened surface. The remedy is a stiffer arbor, attention to the rake and clearance of the teeth, and their spiral disposition. Since the employment of high-speed steel has become general, manufacturers have been compelled to devote close attention to these features. The reason why edge cutters chatter when heavy tooling is attempted is that they do not get below the surface at once, but slide over it. At the commencement, the depth of cut is nil, and the chip is deepest where the cutter leaves the work. When the force tending to deflect the cutter off the work at entry overcomes the incisive action, it will slip, the arbor will bend, and the cutter will not get beneath the metal immediately.

A difficulty relating to the design and manufacture of cutters is, that in general shop practice, the same one has to be used for different materials, on pieces of different substance, from slight to massive, and on machines of various builds. A great advantage therefore is enjoyed by those firms which build machines for special purposes, and can design cutters for a given class of work that is continually being done.

Rake.—Many cutters, the greater number perhaps, have no front rake, but a considerable number have, both the solid forms, and those with inserted teeth. In these and other details the cutters of the present-day illustrate an immense number of variations similar to those which occur with single-edged tools. There is no single detail that has not been the subject of experiment and controversy—the rake, clearance, pitch, the sectional shapes of teeth, speed and feed; and practice still shows variations.

For general service, cutters without front rake are best. For roughing it is desirable, but only if the pitching is coarse, the speed slow, and the arbor, and machine stiff. The amount of rake varies from zero to as much as 15 deg. for roughing. On the other hand many cutters for finishing have a considerable amount of negative rake. Light, yielding, flimsy articles are better tooled with cutters having little or no rake. On heavy, substantial pieces, tools with rake are less liable to dig in than they are with those that are springy. As a set-off against the benefit of rake, there is the fact that its increase weakens the tooth. Being of reduced section it will not carry off the heat so readily as a coarser tooth will do. Neither will its endurance before regrinding, nor its capacity for wear be so great. If its section is increased by way of compensation, the chip space is reduced. These variables have to be balanced against each other.

Clearance.—As in single-edged tools, only a minimum clearance is allowed, just sufficient to prevent rubbing of the tooth on the work. A large amount of clearance will cause the teeth to dig in, and the deeper they go, the more stress is thrown on the arbor, with resulting chatter. It should not exceed from 5 deg. to 8 deg. The strongest and best shape for a tooth is that of a parabola at the rear of the clearance. Two angles are better than one—the real grinding angle or land, and the other behind it, tangential to the parabola. This, like the similar provision in the single-edged tools lessens the amount of re-grinding on the land. This is a stronger form than the triangular. There are two kinds of cutters, to which the term "form," and "formed," are applied. The first is the ordinary kind sharpened on the land. The second, used chiefly for gear teeth, are sharpened on their faces, and the teeth are backed off with a radius struck from a centre which is not the centre of the cutter, and so retain their sectional shape after repeated regrindings, until worn out. The teeth are pitched more coarsely than those of the ordinary cutters.

Two facts which have been demonstrated by experiment, exercise a modifying influence on old practice. One is that a cutter with few teeth will remove a given amount of material with the expenditure of less power than one with many more teeth. But the greater the number of teeth in a given cutter, the more material can be removed per revolution, provided sufficient chip space is allowed. The other is that, using an edge mill, the thin portion of the chip requires, proportionately, more force for its removal than the thick does. Hence it would follow that if the average thickness of a chip is substantial, the work will be done more efficiently than if thinner chips are cut.

Spiral Teeth.—All cutters of over about ¾ in. wide have spiral teeth. These avoid the shock which occurs when teeth set square across, strike the work. They take a shearing cut, lessen risk of chatter, and produce a smoother surface. The angle of spiral may range from 45 deg. to 60 deg. A good many of the narrower cutters are made with teeth set in right and left-hand spirals alternately. This avoids the tendency which a spiral cutter has to push and distort the metal adjacent to the cut in the direction of the spiral. The cutter in which the directions of the teeth alternate is self-corrective because the stresses are reversed. Less power is required than with a cutter having teeth of one hand, or a straight-faced cutter. But the width has to be limited. If it exceeds about 2 in., separate cutters are made to interlock.

In a good many cutters, the teeth are separated into a number of narrow points or edges, instead of being continuous. This favours the breaking-up of the shavings into chips, and lightens the work. It is especially serviceable in the case of heavy slab milling. The continuity is broken by cutting a thread around the teeth. The same principle is embodied in cutters with inserted teeth. The teeth may be blades, or cylindrical plugs, with differences in fastenings. Single blades can be easily renewed, while in a solid cutter the fracture of a tooth means the sacrifice of the cutter. Difficulties of hardening are less with inserted teeth. By whatever methods the cutters are secured they are ground by the same methods that are usual in the case of continuous teeth.

Feeds.—These are variously stated, in advance, in inches per minute, in parts of an inch per revolution of the cutter, and in fractions of an inch per single tooth. The number of cubic inches of material removed per minute is a measure of efficiency. In general, the best results are obtained with a coarse feed and a slow speed. A small decrease in cutting speed will often increase the endurance of the cutter between grindings.

Illustrations of Cutters.—Many of the earlier cutters for performing a rather rough class of work were simply round-nosed tools clamped in heads, just as many roughing boring cutters are made. The action is incisive. They have been used largely on ending machines, rotary planers, for facing the ends of castings and forgings, columns, girders, and

Fig. 137.

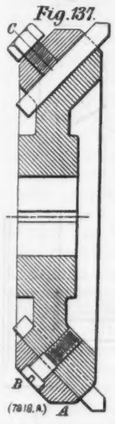


Fig. 138.

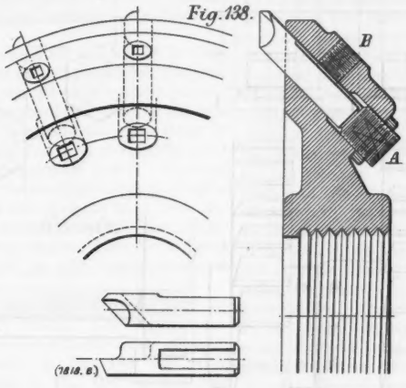


Fig. 140.

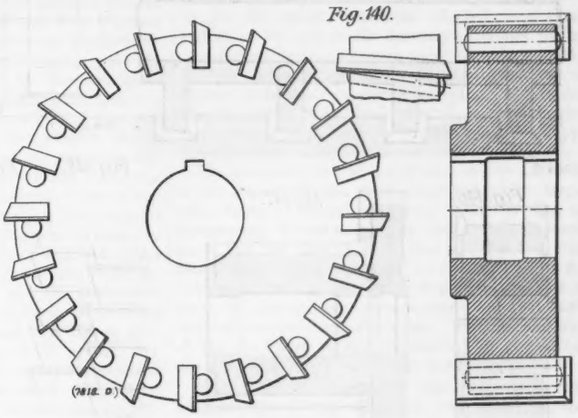
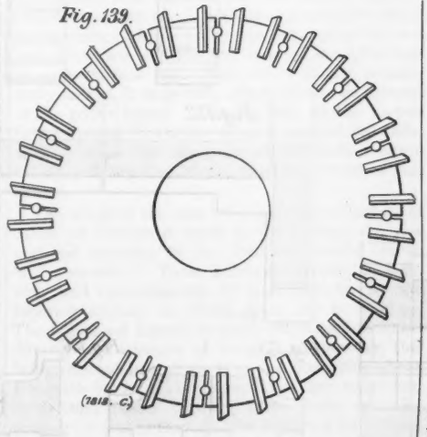


Fig. 139.



similar articles. They are more rapid in action than reciprocating planing machines, and they were in use before the more advanced cutters of the present time were designed.

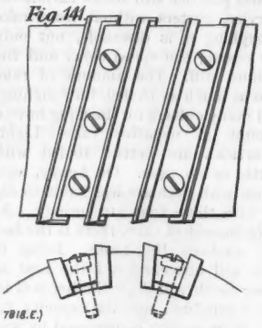
Fig. 137 shows a design in which the cutters, of square section, fit in open slots cut in the bevelled face of the head, these slots being easier to produce than broached holes. The slots are covered by a ring A which is secured to the body by the screws B; the cutters are clamped with the set screws C. A Wrigley face mill is shown by Fig. 138, designed for cutting aluminium. The cutters, one of which is drawn separately below, are of cylindrical section, for which the holes can be readily drilled. They are adjusted radially with screws A at the rear, and clamped with screws B perpendicular to them. Both set screws have recessed heads for a tommy, to avoid unsafe projections, and the adjusting screw A has a lock-nut. The cutters are provided with a shallow groove into which the point of the set screw enters to prevent them from turning round. Some heads have cutters set in perpendicularly to their faces, usually in square holes. These are round nose tools simply, cutting straightforward.

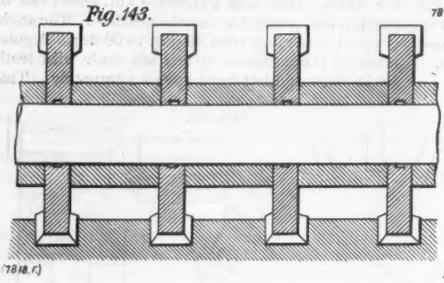
The cutters now mostly used have flat blades, variously secured with screws, wedges and pins for face, and edge milling. Fig. 139 shows a common method. The body has a number of radial splits carried for a little distance inwards, between alternate pairs of teeth. In the centre of each split a tapered hole is drilled and reamed to receive a tapered pin, which, when driven in, exercises sufficient pressure to tighten the adjacent cutters. To remove the blades, the pins are knocked back. The cutters have no front rake, and stand squarely across. A facing head, with cutters set diagonally giving front rake, is seen in Fig. 140. They are secured each with a pin, flattened, and tapered on one face to press the adjacent cutter into its groove. A method is shown in Fig. 141 in which face cutters are secured with a strip pressing against the flanks of those adjacent. The strip does not bear on the bottom of its groove.

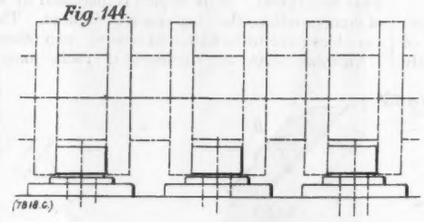
A variation is shown in Fig. 142, in which bushings with flattened faces bear against the blades, being tightened with screws as in Fig. 141.

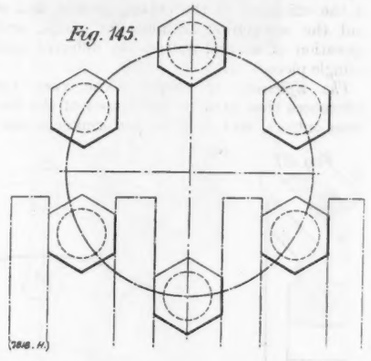
Multiple Arrangements.—While the efficiency of the individual cutters has been vastly augmented, the multiple dispositions have received equal attention. The beginning of this advance is seen in the mounting of cutters in gangs for edge and face work to facilitate the performance of identical operations that would be tediously accomplished with single-edged tools. The cutters are not made solidly as they are for most irregular profile work, but single cutters are selected and mounted on a common arbor with spacing bushes when necessary. They thus embody lateral as well as radial dimensions. Mounting cutters in gangs imposes severe strains on the arbors, which are liable to spring, and produce inaccurate results. Light finishing cuts should be used as a corrective.

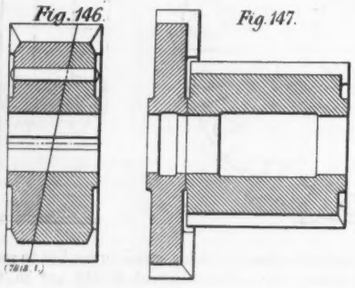
Side milling cutters are often termed straddle mills, when used in combinations. Most of the cutting is done by the teeth on the periphery, and not by those on the sides, which perform a little corrective work, as in slot grooving, and in straddle work. Side teeth are necessary even if they do no cutting in order to leave room for the escape of the chips. Fig. 143 shows a gang of cutters for milling slots, separated by bushes; Fig. 144 shows cutters for milling nuts arranged in tandem. Fig. 145 illustrates a revolving head carrying six nuts or bolts, which are milled as they are brought round into successive positions and locked. Another method

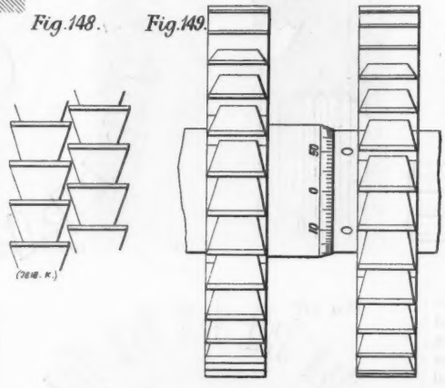


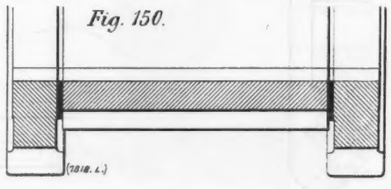


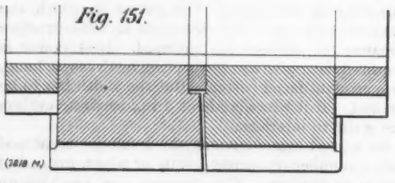


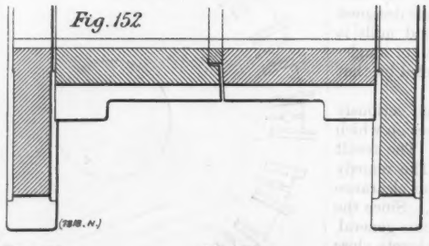


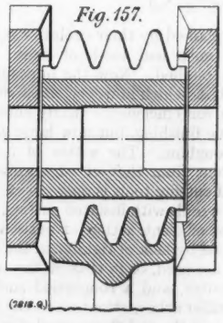


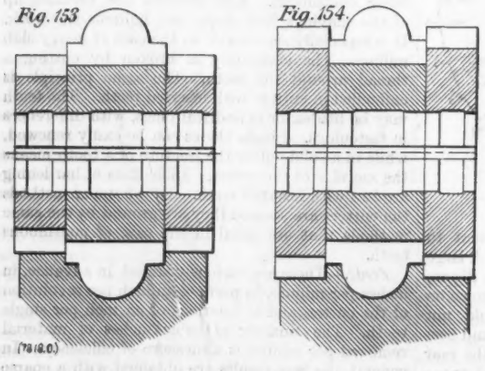


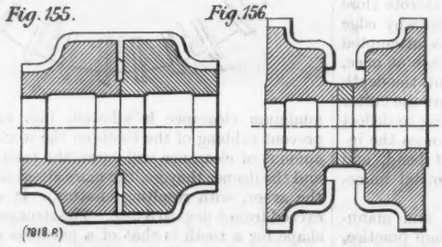


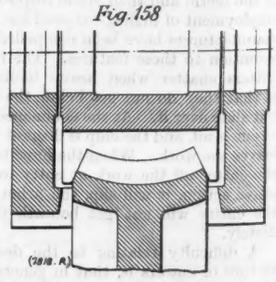












is to string nuts on an arbor, and tool opposite faces with a straddle mill, turning and locking the arbor to bring successive flats to the cutters.

Interlocking.—Built-up cutters are interlocked in various ways. It is often necessary to include provision for effecting adjustments to compensate for wear, so that as the teeth are resharpened the width, or the overall distances are maintained. An old and a satisfactory way of providing adjustment for a simple slot mill is to make it in two thicknesses, with a diagonal joint, Fig. 146. The joint leaves no mark on the work, and packings can be inserted to compensate for wear.

When jointing cutters they should, when practicable, be fitted in a manner best calculated to avoid risk of breaking unsupported tooth edges. Thus, if a small and a large cutter are adjacent the smaller one is better if recessed into the larger, as in Fig. 147. A common method of fitting cutters with interlocking teeth is shown in Fig. 148. This affords protection to the edges, but the amount of interlocking cannot be large.

Fig. 149 shows a method of adjusting the spacings of saddle mills within $\frac{1}{1000}$ in., introduced by the Brooke Tool Company. Instead of fitting a plain collar, as in Fig. 143, a screwed collar is provided with micrometer graduations on a bevelled edge. This avoids the removal and correction for thickness of loose washers.

Some examples of gang mills are shown in Figs. 150 to 154. In Fig. 150 there is no means of adjustment for wear. The central cutter enters slightly into recesses in those that flank it. In Fig. 151 side cutters fit within the central one. The latter is made in two parts, separated with a diagonal joint which prevents the formation of a fin. A central washer provides means for readjustments of length. Fig. 152 is a cutter of the opposite kind from the previous one, but the central body still has a diagonal joint and thickness washer. Any variations in outlines can be built up with combinations of these kinds.

Figs. 153, 154, show that cutters can be built up to render parts mutually fitting. The central form cutter of semi-circular section is flanked with straight cutters of small diameter, in Fig. 153, and with others of larger diameter in Fig. 154, so that the parts tooled register into each other, the parts being a bearing and its cap. Figs. 155, 156, show two divided cutters with provisions for adjustment. The halves in both are packed to maintain the profiles correctly, Fig. 155 outwards, Fig. 156 inwards, substituting thinner washers.

A scheme of multi-cutting is shown in Fig. 157. The arrangement is intended for milling the rim of a sheave wheel for rope or cord, the three grooves and the outer face being tooled at once with a built-up gang cutter. This arrangement completes the job in one setting and gives uniformity of results. An alternative is to tool each groove separately in a lathe or in a vertical turning and boring mill. These may take the place of first roughing operations, leaving the gang cutter to finish the outline. The method is adopted in milling blanks for bevel, and worm wheels, the rims of which are light, as shown in Fig. 158.

(To be continued.)

THE PRESCOT WORKS OF THE BRITISH INSULATED AND HELSBY CABLES, LIMITED.

THE important company, known since 1902 as the British Insulated and Helsby Cables, Limited, is the result of the amalgamation of the British Insulated Wire Company with works at Prescot and Liverpool and the Telegraph Manufacturing Company, Limited, of Helsby. The British Insulated Wire Company started its Prescot works in 1891, primarily for the manufacture of paper-insulated cables, and this still remains the most important production of the works in question, although large departments of the factory are devoted to electric railway and tramway equipment, electric welding machinery of all kinds, aluminium sheets, rods and wire, electric fans, paper pinions and other specialities of the firm. The manufacture of rubber-insulated cables, is carried on at the Helsby Works, where electrical condensers for power-factor improvement and other apparatus are also made. It may be mentioned that golf balls also form quite an important item in the production of the Helsby Works. The company is thus in a position to supply not only every kind and size of wire or cable that is used in electrical work, from its own factories, and to take contracts for railway and tramway electrification, but to supply many other products for the manufacture of which the various works have special facilities.

The Prescot Works, which alone will be dealt with in the present article, now cover 30 acres of land, of which 18 acres are roofed over and occupied by workshops of various kinds. Their utmost continuous expansion during the last thirty years from their original small beginnings has caused the arrangement, and indeed the design of some of the shops, to be somewhat less convenient than those of a new factory with departments laid out simultaneously for a definite output, but in equipment and organisation there is nothing lacking for work of the very highest class. The ground plan, Fig. 1, on page 676, bears evidence of the growth to which we have referred, the later and more modern shops being those on the western side. The entrance to the offices and works is directly opposite Prescot Station, a few yards away, and this fact, together with the railway tracks running through the factory, gives excellent facilities for transportation. As the principal shops are indicated by the references tabulated below, Fig. 1, we need not enter into any lengthy description of their arrangement. Power is supplied from the company's own station within the works, which was put down thirty-one years ago for the purpose of lighting Prescot and Knowsley Hall, and incidentally for the demonstratian of the efficiency of paper-insulated cables. The original 48-kw. of plant has been increased to a rated capacity of 5,100 kw. at the present time, which supplies not only the works, but an external area of 22 sq. miles, for which the company are the authorised undertakers. This external supply is distributed by 100-cycle, single-phase current, but this is now being changed to a frequency of 50 cycles, and arrangements are being made to supply three-phase 50-cycle current throughout the area. This is in conformity with the standard system throughout the Mersey and West Lancashire District and will enable interconnections with other areas to be made. In pursuance of this policy the last generating unit put down was a 1,750 kw. three-phase 2,200-volt 50-cycle turbine set. This set is shown prominently in Fig. 2, page 686, which shows the interior of the power house. The majority of the motors in the Prescot Works use direct current at 240 volts, and all the older main generators, both reciprocating and turbine driven, produce current of this nature.

The whole of the wire used in the manufacture of cables at Prescot is made in the factory, the raw material entering in the form of copper billets, or "wire-bars." These billets are about 3 ft. 9 in. long, and approximately 3¾ in. square, the section tapering slightly in width from top to bottom. The billets are heated in muffle furnaces and rolled directly into wire-rod of about ¼-in. diameter, this being effected in a single heat and occupying about 1 minute for its performance. For this reduction, each billet passes through three trains of rolls, making 11 passes through the roughing rolls, three through the intermediate rolls, and seven through the finishing rolls, or 21 passes in all. The wire, of course, gains in linear speed as it goes through the successive passes, and it is interesting to watch the dexterity of the operators in catching the end as it travels along the steel floor and returning it through the next pass. Each set of rolls is capable of a production of over 30 tons of wire in a shift of 8½ hours, so that when the three sets are all running, an output of about 100 tons per day is obtained.

After leaving the final pass the wire is automatically wound into a coil by a power operated winder. It is next annealed by reheating in a muffle furnace and plunging while still hot into a tank of water. The annealed wire is then pickled in a weak acid bath to remove the scale, when it is ready for drawing. Reduction from the size of the wire rod, from ¼ in. diameter down to No. 16 gauge, is effected in one operation, the wire being drawn through nine consecutive holes. There are 22 drawing machines for this purpose, the output of each machine being about 2 tons of wire per shift. Sizes larger than No. 16 gauge are usually drawn down on single block machines, especially when a high tensile wire is being made, such as Post Office line wire, telephone wire, trolley wire, &c. For wires smaller than No. 16 gauge, the first drawing operation is followed by a bright annealing process. This is carried out in a Bates and Peard continuous annealing furnace, the coils of wire being placed on the bars of an almost imperceptibly-moving chain conveyor, which carried them down through a water tank, then through the furnace and out again through another water tank. These tanks are arranged to seal the inlet and outlet of the furnace muffle, so that air cannot obtain access to the interior. Thus a completely non-oxidising atmosphere is maintained in the furnace, and although the wire is raised within it to a temperature of 1,150 deg. F., it is delivered in a perfectly bright and clean condition. An illustration of one of these Bates and Peard furnaces is shown in Fig. 3, page 686, which gives a view of one end of the annealing shop. The next reduction in size is to No. 28 gauge, which is effected in a single operation by automatic drawing machines having 10 consecutive holes through which the wire is pulled. For sizes less than No. 28, the wire is drawn down on further automatic machines carrying 16 diamond dies in series. The final product is then bright-annealed by Bates and Peard furnaces of the type already mentioned.

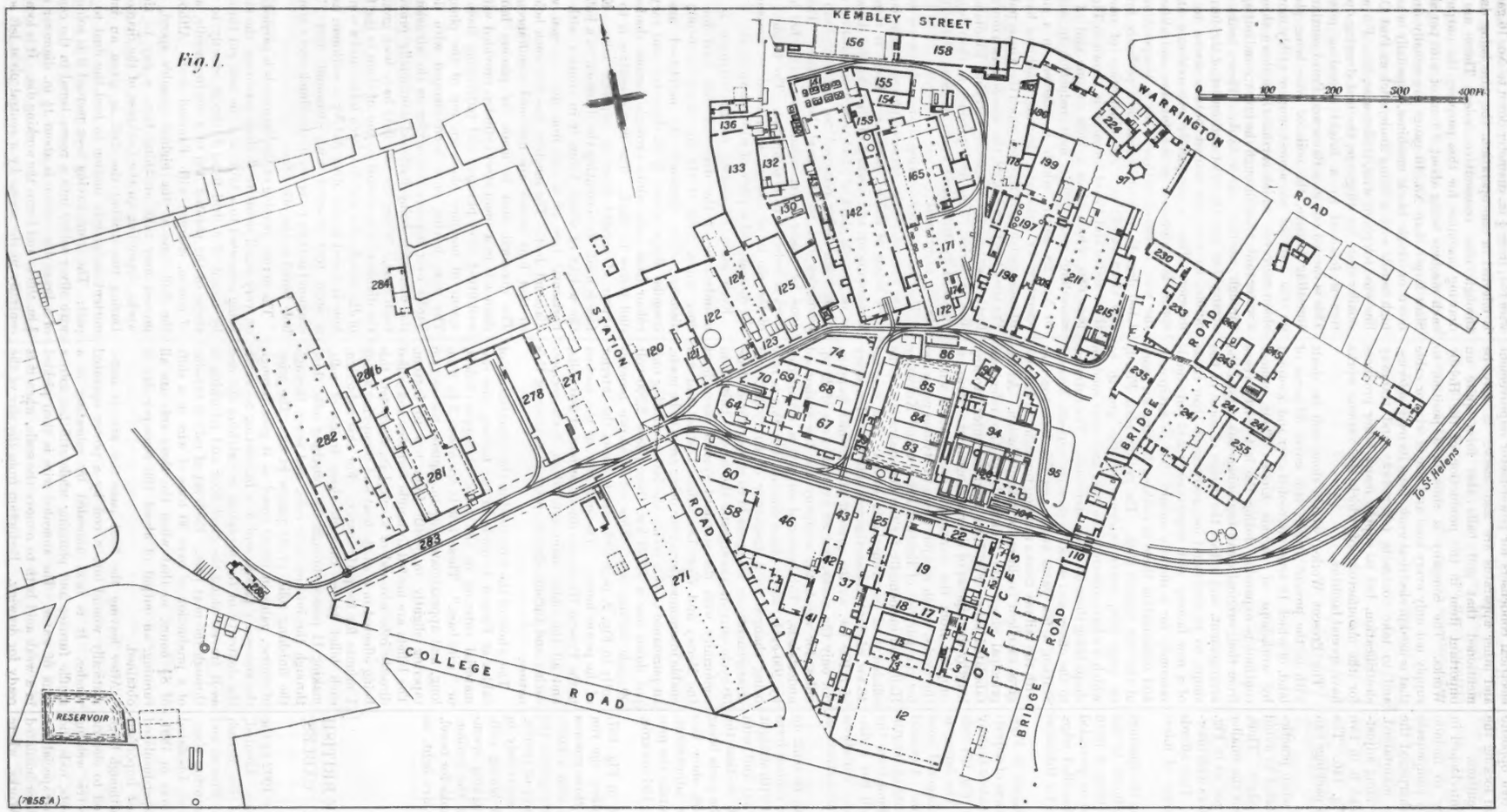
The dies used for drawing all sizes of wire are made in the Prescot Works, those employed for the larger sizes being of chilled cast-iron. There is thus no hammering up and resizing of dies by the drawers, as in the old days of steel dies, the cast-iron dies when worn being returned to the tool shop for reamering out to the next larger size. This is done by power-driven square reamers so that hand work is reduced to a minimum. The finished size of the die is, of course, determined by measuring the diameter of a piece of wire drawn by it.

Even more interesting to the engineer is the manufacture of the diamond dies used for the finer wires, from 0·014 in. down to 0·002 in. diameter. The diamonds as purchased are of irregular shape, about $\frac{1}{16}$ in. diameter, and vary in colour from pure white through various shades of dull yellow to black. The first operation is to get a pair of parallel faces on opposite sides. Each face is made by cementing the diamond to a holder, the weight of which keeps it in contact with the horizontal face of a cast-iron disc charged with diamond dust. The machine has four such holders so that four stones are flattened simultaneously. The diamond dust is made by placing broken diamonds in a small steel cylinder, provided with a well-fitted steel plunger, and pulverising them by means of hammer blows on top of the plunger. The disc, having once been charged with dust, hardly ever requires re-charging as the abrasion of the diamonds being flattened continually provides fresh dust. When the two flats have been ground, the diamond is cemented by one of them to the face of the chuck of a watchmaker's lathe, and a conical hole is bored in the other flat by a workman using a steel tool charged with diamond dust. The diamond is then reversed in the chuck and a similar hole bored in the other face.

The actual piercing of the diamonds is carried out on very small sensitive drilling machines, the stone being cemented to a table and the hole put through by means of a drill formed almost exactly to the shape of the pointed end of a sewing needle, and, of course, charged with diamond dust. Although the drill runs at the highest possible speed, the process may take anything from a day to three weeks, depending on the thickness of the diamond. During the drilling the drill is given an intermittent reciprocity motion to feed the dust to the part. The stone having been pierced it is soldered with silver solder into a recess bored in the centre of a brass disc, which is about 1½ in. diameter and ½ in. thick, and forms the working die. It is located centrally in the recess by a central pivot left solid

THE PRESCOT WORKS OF THE BRITISH INSULATED AND HELSBY CABLES, LIMITED.

Fig. 1.



REFERENCES.

1 to 3. General Offices.
12. Insulating Room No. 2.
13 to 15. Ovens.
17 and 18. Paper Room.
19. Insulating Room No. 1.
22. Copper Stores.
25 and 26. Pump Rooms.
37 to 41 to 43. Lead Covering Department.
46. Insulating Room No. 3.
58 to 60. Scrap Copper.
64. Copper Refinery.
67 and 68. Fine Wire Drawing.
69 and 70. Copper Packing Room.
74. Tinning Shop.
79. Ambulance Station.
83, 84, 85 and 86. Cooling Towers.
94. Electric Power Station.
95. Coal Store.
96. Oil Store.
97. Water Tower.
100. Boiler-House.
104. Locomotive Shed.
110. Motor Garage.
120. Copper Wire Drawing.
121, 123 and 124. Annealing and Pickling Shops.
122. Copper Wire Rolling Mill.
125. Aluminium Rod Mill.
130, 133 and 136. Aluminium Sheet Mill.
132. Joiners' Shop.
140 to 143, 149 and 153 to 155. Extruding Department.
156. Timber Store.
158. Welding Machine Department.
165. Mechanics' Department.
171, 172 and 174. Smithy and Tinsmiths' Shop.
178, 180 and 186. Drum Shop.
197. Brass Foundry.
198. Fitting and Assembling Shops.
199. Hammer Shop.
209. Stores.
211. Electrical Fittings Department.
215. Box Finishing Shop.
224. Electrical Fittings Department Offices.
230. Welders' Drawing Office.
233. Reactance Shop and Meter Test-Room.
235. Casting Stores.
241. Iron Foundry.
242 and 243. Wire Department.
245. Pattern Shop.
255. Brass and Iron Foundry.
271. Telephone Cable Department.
277. Offices and Stores.
278. Cotton Covering Department.
281. Test-House.
281B. Extension to E.H.T. Testing Bay.
282. Armouring Department.
283. Export Shed.
284. Light and Power Department Shop.
286. Incinerator.

with the disc when the recess is turned, this pivot entering the coned hole in the diamond. Its axial position is further ensured by a jig which holds the die and contains a fine wire plunger which descends into the hole from the top. When thus held, the soldering operation is carried out. The other side of the disc contains a small central recess which locates the disc in the jig, and when the diamond is soldered in, this recess forms the start for a drill which makes the necessary hole through the disc to the back of the diamond. The die is then opened out to exact size and contour of hole by a needle reamer charged with diamond dust and used in a tiny kind of bench lathe. As in drilling, the reamer is automatically reciprocated intermittently. The delicacy of the work will be imagined when it is remembered that the hole must not only be smooth and circular with a lead-in of proper shape, but the margin of error permissible in a wire of the nominal diameter of one or two thousandths of an inch only, is absolutely inappreciable. When the die becomes worn by use, it is reamered out to the next larger size by a method similar to that last described.

We do not propose to deal with the processes of stranding, insulating, armouring, &c., which go to make up the finished cables of various kinds, but a brief reference to the method of covering the cables with the familiar lead sheath may be made. The lead is put on by hydraulic presses, which extrude a pipe round the cable as it is passed through. The largest press is capable of exerting a total pressure of 1,900 tons. The table carries a steel container heated by gas jets which holds lead in a plastic condition at a temperature just below its melting-point. The container is filled up from time to time by molten lead run in by a shoot from a melting furnace, but this temperature is lost before the lead is extruded, as there are always at least two charges already in the container when it is refilled. As the table rises a 9-in. ram enters the container, which it practically fits, and forces the lead out through the dies under a pressure of about 26 tons per square inch. The dies consist essentially of a pair of cones with their smaller ends cut off. Each cone is bored out so that its truncated end terminates in a comparatively sharp edge, the hole through one cone being a nice fit for the uncovered cable, and that through the other being the diameter of the covered cable. These cones are set axially with their small ends pointing together. The end of the first just penetrating the bore of the other. The tapered faces of the cones which are, of course, inside the holder, are surrounded by lead, the internal walls of the holder sweeping round to meet the cones by easy curves. The lead, forced down from the container, can only escape by flowing out through the annular space left between the ends of the cones, so that it emerges from the hole in the larger cone in the form of a tube. A uniform flow to the orifice is ensured by the internal shape of the die-holder, and the latter also contains a bridge above the die points to deflect the lead to each side and reduce the direct pressure which would otherwise occur at the upper side of the orifice. The emerging lead is not hot enough to char the paper wrapping of a cable in the slightest degree, and the cable is in no way pinched by the covering, which is merely a good fit over the surface of the interior portion. As the covered cable leaves the press it is wound on a drum, ready for any further operation which its nature demands.

All sizes of lead covering are made in the manner described, the elliptical sheathing used to protect twin wires for domestic wiring being extruded in the same way, the dies, of course, being shaped to give an annulus of the required section. The smallest lead covering ever made by the British Insulated and Helsby Cables, Limited, was some which was successfully extruded over a copper wire 0·020 in. diameter. The finished wire was 0·030 in. diameter over the lead sheathing, so that the lead itself was no more than five one-thousandths of an inch thick.

The first test of a lead-covered cable consists in its immersion in water for 24 hours, after which its insulation is measured. The object of the water test is to find out any minute pin holes which might exist in the sheathing, and large concrete tanks are provided for the purpose. A standard 33,000-volt cable is subjected to a pressure of 75,000 volts applied between two of the conductors, and the third conductor connected to the lead sheath. A 44,000-volt cable is similarly tested with 90,000 volts, the voltage being applied continuously for 15 minutes in each case. Should any defect in the insulation be observed, the whole length of cable is destroyed, the lead covering being stripped off and the internal parts cut into lengths and melted down to remove the insulation. No repair of the lead covering by soldering or otherwise is permitted. For breakdown tests of cables, pressures up to 260,000 volts can be applied. Tests of electrical capacity and resistance are also applied, the capacity test of telephone cables in particular being a matter of considerable importance. The capacity of such cables is affected not only by the nature and quantity of the dielectric separating the hundreds of individual wires, but also upon the tightness with which these wires are stranded together.

Telephone cables have been made at Prescot containing as many as 1,350 pairs of wires. Each wire is insulated by a spiral wrapping of paper, two such wires are then stranded together to form a pair, and finally two pairs are stranded together to form a quad. Each quad is held together by an open wrapping of paper tape, and then the whole of them are stranded together to form the complete

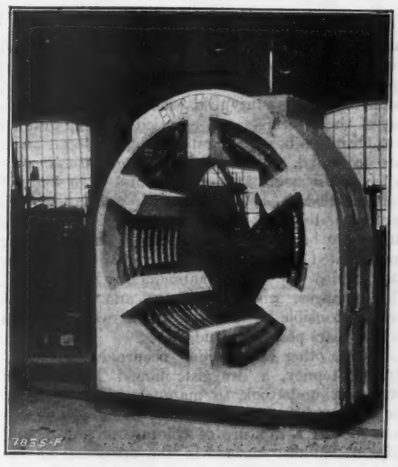


FIG. 6. OPEN TYPE REACTANCE.

cable. This is wrapped with paper and finally covered with a lead sheathing as already described. By the use of different coloured paper the various wires of a quad are readily distinguished from each other. For the insulation test, the corresponding wires of all quads are connected together, and each group tested with a pressure of 60 volts between the other groups and earth. The overall diameter of these large telephone cables is 3½ in. or so, and the length in which they are made is only limited by the question of transportation. A common length is about 220 yards. The most imposing drums of cable which are sent out from the works are, however, those containing 33,000-volt armoured cable for laying direct in the ground, such as is now largely used for trunk interconnecting mains. These drums, which carry about 750 ft. of cable, are about 9 ft. diameter and weigh close on 7 tons each. A view of the telephone cable-making shop is given in Fig. 4, page 686. The last illustration on that page, namely Fig. 5, shows the shop where the armouring of cables is carried out. The shop is at present full of armouring machinery, but the photograph taken before the later machines were put in serves to show the general construction of the buildings.

A considerable amount of aluminium work is done by the British Insulated and Helsby Cables, Limited, at Prescot. This is not so much for electrical purposes, although aluminium bus-bars and overhead lines are among the products, as for the requirements of other trades. Sheet aluminium is rolled for motor car body builders, and the familiar corrugated aluminium running board mats are also made at Prescot. The aluminium arrives in the form of thin cast slabs or cylindrical billets. The slabs, which measure 28 in. by 14 in. by 2 in. thick, are of 98 per cent. to 99 per cent. purity. They are heated in furnaces to about 500 deg. C. and then broken down by about 8 or 10 passes through rolls to a thickness of about ⅛ in. They are then taken to other rolls where their thickness is reduced to about ¼ in. This reduction is effected by repeated passes backward and forward through the same set of rolls, the operator adjusting the rolls as required, and maintaining the thickness of the work even by noting the shape the sheet tends to take during the process. No annealing is required in the rolling of aluminium. Upon leaving the rolls mentioned, the sheet is examined for surface flaws and blisters which result from surface defects in the original slab. These are scraped out by hand, and the sheet is completed by a few more passes between the rolls, which remove the scraper marks.

A thin rolled sheet, whether of aluminium, or any other metal, will always present certain signs of "buckling" and to get the absolute flatness which is desirable, the sheets are stretched. This is done by a horizontal hydraulic machine in which the ends of the sheet are held in toggle grips, and a stretch of an inch or two given to the work. This is the final operation for all rolled or extruded work in which perfect flatness and straightness is necessary. There is a considerable demand for aluminium sheets with a "satin" finish, instead of the bright finish left by the rolls. The satin finish is given by a machine which operates on the sheet with a rapidly revolving wire scratch brush. The aluminium matting used so largely in motor cars is made by passing the sheet through a mill in which one of the rolls is grooved. When a cross-pattern is required, the sheet is passed first longitudinally and then sideways through the same rolls. Six patterns of matting are made by the company. Matting of this kind, when used on running-boards or stair-treads requires suitable edging round the corner of the step. This is made by extruding aluminium of the required section, which is some kind of angle-shape with non-slipping grooves along the top flange.

For the extrusion process, aluminium billets are heated to a dull red heat and put in the container of the extrusion press, which is a horizontal hydraulic machine. The ram entering the container forces the metal out through dies of the shape required, and it emerges perfectly correct to section in a single operation. Straightness is given to the finished strip by stretching, as in the case of sheets. Sections can readily be extruded which could not possibly be made by rolling and the process is vastly quicker than drawing, even could as satisfactory a job be made by this means.

One of the numerous special activities of the British Insulated and Helsby Cables, Limited, is concerned with the manufacture of paper pinions. These are made in the mechanical department of the works, whose other duties comprise the maintenance and repair of all the machinery in the factory. This department is also responsible for the design and manufacture of much of the equipment of the factory, for most of the machines used are made by the company themselves. The material used for the paper pinions is grey manila paper, which is purchased in sheets of a thickness of about 0·004 in. Discs of this paper are punched out to the required size and assembled, in all but the smallest pinions, on a cast-iron sleeve which forms the bore of the pinion. The discs, together with the metal end-cheeks are assembled under hydraulic pressure, and drilled and riveted together when cramped in special jigs. The paper is assembled in its natural dry state for ordinary pinions, but for those which have to work in wet places, or where steam or moisture is present in the air, the paper discs are saturated with oil before being pressed. The final operation is the cutting of the teeth, which are milled out on ordinary gear-cutting machines.

The self-contained nature of the Prescot Works is indicated by the fact that the firm manufacture all the iron, brass and gun-metal castings used in connection with their ordinary products, and even make their own malleable castings. The drums on which the cables go away are also made in the works, as are the drum carriages on which they are

transported by road. The large number of old and damaged cable drums which are returned to the work are broken up and used as firewood, this operation being carried out as systematically as any productive process. The drum sides, which are full of clinched nails, would take an inordinate amount of breaking up by hand, so they are taken to a specially-designed power-driven punching machine, which punches each nail right out through the wood when the operator's foot depresses a pedal. Removal of all nails in this way makes the boards fall apart. They are then cut into short lengths by a circular saw and split into firewood by a firewood-making machine.

Among the electrical apparatus other than cables which the company manufacture should be mentioned the large reactances which are provided for the safety of generators and switchgear. Power stations are now constructed on such a large scale, and the individual generating units are of such a magnitude, that the occurrence of a short circuit or fault on the system might be attended with very serious consequences. The function of a reactance, which is really a large choking coil without iron in the magnetic circuit, is to limit automatically the amount of current which can flow through a fault, and so to provide against the switchgear having to break currents which would be beyond the capacity of the apparatus. In the case of very large generating units the best practice is to insert a reactance in the bus-bar system between every pair of machines, to limit the current which can be fed into a faulty machine by others running in parallel with it. Reactances are also inserted in feeders to limit the current which will flow through a fault occurring near the power station, and have been used for a long time to replace resistances in the earth connection of the neutral point of generators. A typical reactance, as made by the British Insulated and Helsby Cables, Limited, is shown in Fig. 6, page 677. The frame, which much resembles that of a direct-current generator, is made of concrete, the only metal used being brass connections to strengthen the attachment of the internal brackets. These are cast separately at various points around the circumference of a loosely-wound coil of lead-covered cable, and the whole is then bolted and cemented into the separately cast framing. The cable is of the four-core type, and the cores are so connected that the complete coil has four times as many turns as the cable. The terminals are brought out at the top of the framing, and protected by the cast-iron terminal box which can be seen in the illustration.

With the manufacture of ceiling fans, tramway and railway equipment, electric house meters, electrical welding machines and other specialities of the Prescot Works, we have not space to deal on this occasion. Some years ago we illustrated and described very fully the electrical welding machines as then made by the company, and this branch of activity has continued to progress in a most satisfactory manner. Automatic machines are constructed for spot-welding, seam-welding, butt-welding, barrel-making, bicycle-rim making, chain making, and many other purposes. The speed and convenience of this method of jointing metals, and the wide range of purposes to which it may be applied, makes electric welding a necessary adjunct to many manufacturing processes. The exigencies of space also forbid more than the briefest reference to the organisation and equipment of the factory for testing both the finished products and the components at various stages of their manufacture. As a matter of ordinary routine, appropriate mechanical, physical, electrical, chemical or microscopic tests are carried out upon the materials used, in order to maintain the high reputation which the firm has earned for the uniform excellence of its products.

ACCIDENTS WITH EXPLOSIVES IN 1922.

FROM the annual report of H.M. Inspector of Explosives just issued, it appears that for the first time on record no fatal accident occurred in any authorised explosive factory, although the year was marked by two very serious explosions on unlicensed and uninspected premises. Of these the most serious was the disaster at Tipton where the manager of a brass foundry purchased some 160 tons of miniature rifle ammunition to be broken up for the brass and lead. The work was being carried out by young girls, who prised the bullets out of the cartridges and emptied the fine grained powder into a box, preparatory to throwing it away into a canal. Practically no precautions were taken, a fire being kept up within 4 ft or 5 ft. of the work bench, although the air was laden with explosive dust. It is not surprising that a fire ultimately broke out and the girls' clothing being impregnated with powder, 12 were killed on the spot, whilst seven died subsequently in hospital. The manager, whose ignorance and carelessness were responsible for the catastrophe, was sentenced to five years penal servitude.

In the other case, which occurred at Sidney-street, Stepney, a druggist named Mrs. Rachel Ginsburg, undertook to manufacture a "powder for use instead of fireworks," by blending together in a mortar a mixture of chlorate of potash and sulphur. Whilst engaged in the operation an explosion occurred, killing her instantly, whilst two other people were injured. Further fatal accidents are reported with war trophies, but it is satisfactory to learn that the owners of these are taking alarm and calling in the aid of the police to ascertain whether or no their relics are really innocuous. In one case it turned out that some filled high-explosive hand grenades and a filled gas hand bomb had been kept on the owner's mantelpiece for three years, and it was only when the gas liquid began to leak that alarm was taken.

One theft and one attempted theft of explosives for criminal purposes are reported. In the successful case the thieves got away with 40 lb. of gelignite from a magazine at Cambuslang, Lanarkshire. It is satisfactory to note that with the return to peace conditions the accident list has fallen below the average for the years 1905 to 1913. In that period the yearly average was 434·5 accidents, involving the death of 56 persons and injuries to 434 others. Last year the total number of accidents was 380; the deaths numbered 52, whilst there were 373 cases of injury. The report shows that less than 3 per cent. of the accidents causing death or injury to the person occurred in the legal manufacture of explosives. The vast majority of such accidents arise during transport or use. Several bad accidents have occurred with vessels which had been used for storing petrol or other inflammable fluids. The residual vapour forms an explosive mixture with the air and the ignition of this either by ignorance or design has caused several wrecks. In one case children straying on premises where empty benzol barrels were stored removed the bung from one and ignited the contents. Though five were injured by the subsequent explosion, fortunately none were killed.

The report calls attention to the coolness and pluck of two men in charge of a motor lorry carrying petrol tins who, when a fire broke out, stuck to their posts until they had driven clear of all buildings and ditched the car. They had just time to escape clear when the petrol tins burst. As is well known, lyddite is essentially picric acid; nevertheless this dangerous high explosive may burn away quite quietly without detonating. A notable instance is recorded in the report, which states that some 200,000 lb. of picric stored at the U.S.A. Reserve Depot, Wiscousin, was accidentally ignited and burnt away in 30 minutes without exploding. The heat generated was so intense that the metal on the roof of the store and on the hoops of the barrels was melted, and in some cases globules of the molten iron ran through the picric acid.

8½-IN. CENTRE HOLLOW SPINDLE "BUCKMAN" LATHE.

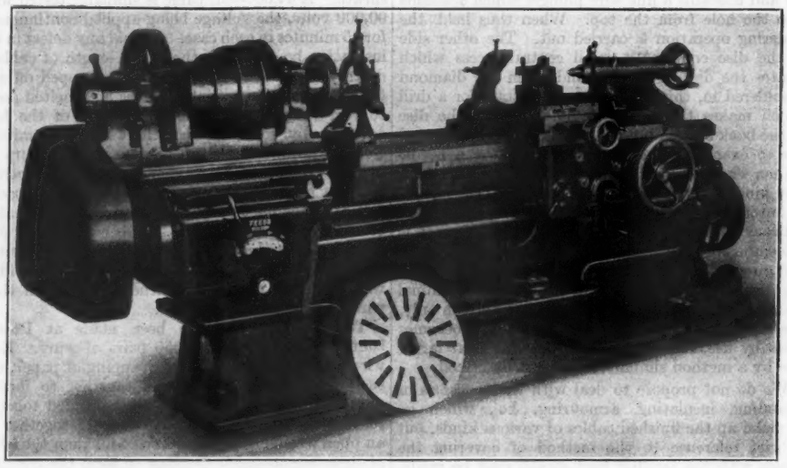


FIG. 1.

8½-IN. HOLLOW SPINDLE GAP LATHE.

WE illustrate in Figs. 1 to 12, on the present and opposite pages, a new pattern of lathe recently introduced by Messrs. Buck and Hickman, Limited, of Whitechapel-road, London. The lathe is known as the 8½-in. Buckman lathe, being built for Messrs. Buck and Hickman by Messrs. J, Holbrook and Sons, of Stratford, E. As will be seen in Fig. 1, the machine has a very strong and serviceable appearance, and an inspection of its details confirms the impression that it should give a very good account of itself on any class of work within its range. It is driven from a two-speed countershaft running at 80 to 265 r.p.m., by a 3-in. belt on a three-step cone pulley, the diameters of which are 8 in., 10 in. and 12 in. The hollow spindle is of large diameter bored to 2 1/16 in., the spindle thrust being taken by a large Hoffman thrust bearing, as may be seen in Fig. 2. The front bearing of the spindle is 4 in. in diameter by 5⅛ in. long. Overall the lathe has a length of 11 ft. 1 in., while it will take between centres work 48 in. long. The height of centres is taken as 8½ in., or a swing of 17½ in. over the bed. Over the saddle a swing is obtained of 11½ in., while at the gap, work requiring a swing of 34 in. can be accommodated. The clear width of the gap measured from the face plate is 10½ in.

A feature of the lathe is the combination of English with American vee-ways. The headstock is bedded on vee and flat ways, the saddle and tailstock are also supported on both flat and vee-ways. Details of the bed are given in Figs. 4 to 7, the last being a section showing the shears. The bed, the design of which is covered by patent, is a particularly robust form of box-casting, the full depth of the box being carried practically all the length of the bed, and, with the internal ribbing, providing a casting of great rigidity.

The lathe is arranged for screw cutting, sliding and surfacing work. The lead screw is used for screw cutting only. At the tail stock end it is supported in double ball thrust bearings. The lead screw is engaged by depressing a small handle on the left hand of the saddle apron. Figs. 8 to 12 give details of the saddle apron gears. Fig. 11 shows the lead screw clutch, which is arranged to engage the lead screw both on the

8½-IN. CENTRE HOLLOW SPINDLE "BUCKMAN" LATHE.

Fig. 2.

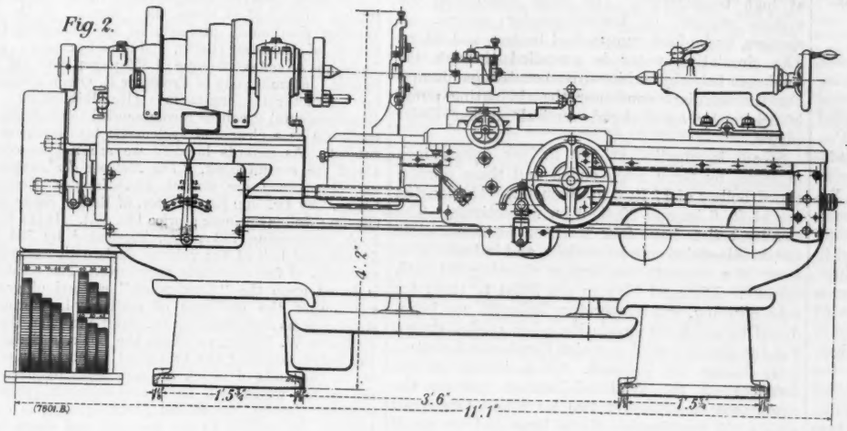


Fig. 3.

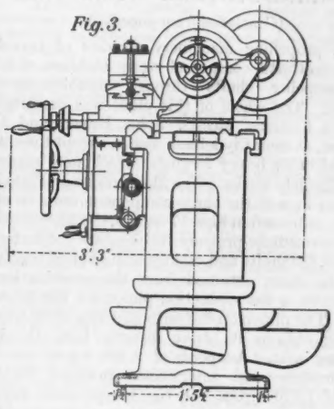


Fig. 4.

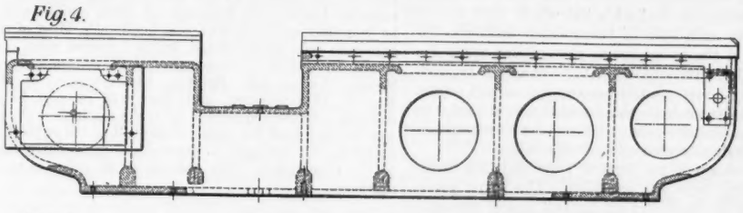


Fig. 6.

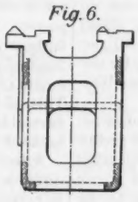


Fig. 5.

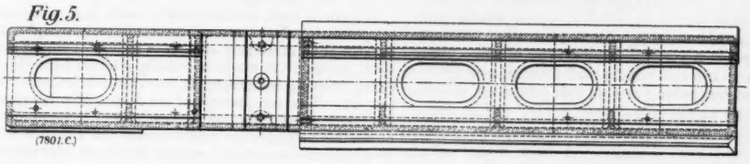


Fig. 7.

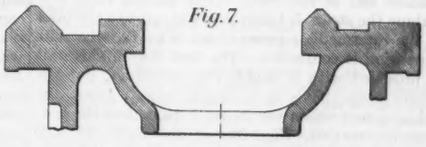


Fig. 8.

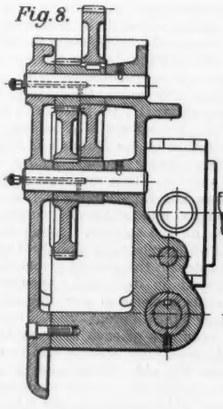


Fig. 9.

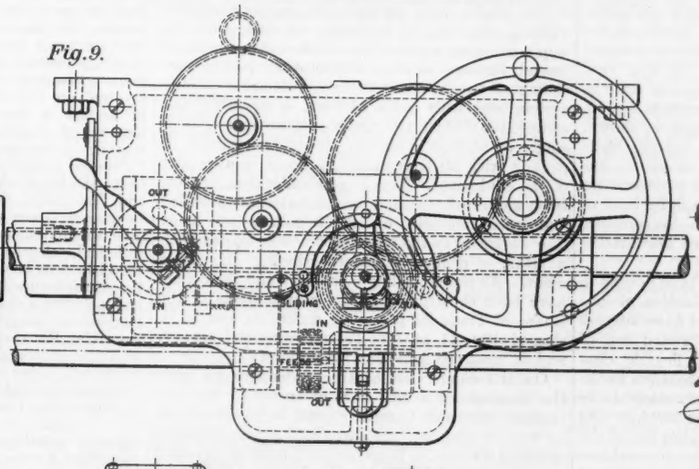


Fig. 10.

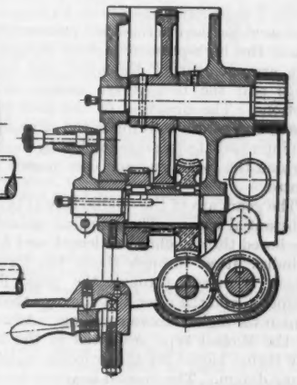


Fig. 11.

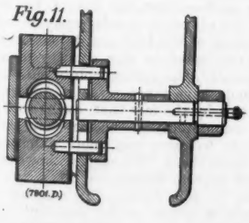
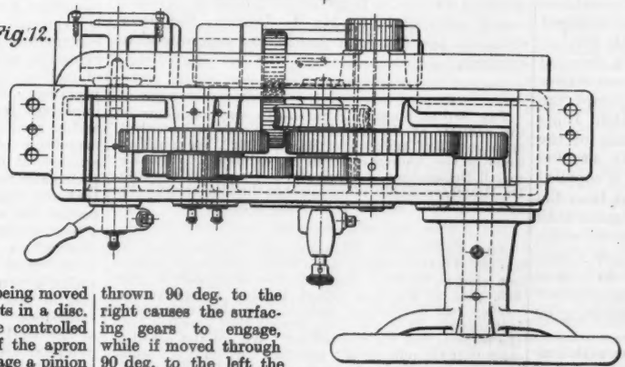


Fig. 12.



top and bottom, the two parts of the nut being moved out or in by two pins working in spiral slots in a disc. The sliding and surfacing movements are controlled by two levers. By one at the bottom of the apron (Fig. 10) a tumbler is raised in order to engage a pinion driving a sliding worm, the latter driving a worm wheel on a small eccentric throw-over spindle. The latter is controlled by the second handle, which if thrown 90 deg. to the right causes the surfacing gears to engage, while if moved through 90 deg. to the left the sliding gears are engaged, the latter working on a rack fixed under the front shear. The apron gears are all well supported by spindles extending between the back and front walls of the apron. A guard is provided over the lead screw to ensure turnings, &c., falling clear of it.

The feed gear-box below the headstock provides four rates of feed, viz., 14, 28, 56, 112 cuts per inch. A lever is provided at the headstock, with tumbler gear, for right and left-hand feeding.

The equipment includes countershaft, steadies, 17-in. face plate, change gears, &c. The machine uses tools of 1¼ in. section. The lathe is provided with large oil trays. Two surround each leg, and these drain into a large central tray hung under the middle of the machine. The latter tray is provided with a large sump extending out towards the back of the machine, as shown in the end view, Fig. 3, in a manner which adds greatly to the convenience in clearing away the swarf, &c.

THE CUNARD TWIN-SCREW GEARED TURBINE-STEAMER "FRANCONIA."

(*Concluded from page* 652.)

THE propelling machinery consists of two sets of Brown-Curtis compound steam turbines, driving the propeller shafts through double-reduction gearing. The whole of this plant was constructed by the builders, Messrs. John Brown and Co., Limited, at their Clydebank works, except the shafting and other heavy forgings, which were made at their Sheffield works. The illustrations on Plate XL are drawings of the three component units in each set. As indicated in Figs. 17 and 19, the high-pressure and intermediate-pressure turbines are connected in tandem, the shafts and casings being bolted together, and the drive obtained from the combination is carried to a first-reduction pinion on the inboard side. The pinion on the outboard side of each set of gearing obtains its drive directly from the low-pressure unit. A speed of 2,750 r.p.m. for the high-pressure and intermediate-pressure turbines and of 1,770 r.p.m. for the low-pressure turbine is reduced in the double-reduction gearing to obtain 90 r.p.m. for the propeller shaft. Each set of turbines gives 6,250 s.h.p., making the total ahead power for the vessel 12,500 s.h.p. About 70 per cent. of that is generated for astern running, by the astern units incorporated within the intermediate-pressure and low-pressure turbine casings.

The high-pressure set, Fig. 17, consists of three double-bladed discs with intermediate nozzle plates. A valve in the inlet pipe, which may be operated by a hand wheel, covers the entrance to a nozzle through which steam may be passed directly to the exhaust end of the unit. After passing from this turbine the steam is taken in a 9-in. pipe to the inlet of the intermediate-pressure set, Fig. 19, where its expansion is continued. The first disc of this unit is provided with a double row of blades, but the other seven have only single rows. From the exhaust connection the steam is passed to the low-pressure turbine, Fig. 20, on the outboard side where a further expansion of the steam is conducted in 11 stages. The astern units are shown in the casings at the after end of the intermediate-pressure and low-pressure turbines, and Fig. 18 is a view of the low-pressure one drawn to the same scale as that used for the intermediate-pressure unit, Fig. 19, where the high-pressure astern turbine is shown. The arrangement of the fixed and moving blade rings and the nozzles are clearly shown in the sections. The direction of the flow of steam for ahead and astern working is the same in the case of the intermediate-pressure set, but in the low-pressure turbine the steam in each case passes towards the centre.

The gears are of the double helical type housed in substantial cases. The two first reduction pinions are bored throughout their length and have internal spindles fitted through them, the forward end of which is driven through the usual flexible claw coupling, and the after end conveys the drive to the pinion through a sleeve coupling. Adjusting blocks of the Michell type are fitted to the turbines and the thrust blocks for the propeller shafts are of the same design. The journal bearings for the turbines and the gearing and all the thrust blocks are arranged to work under forced lubrication. For this purpose there are three direct-acting pumps which draw oil from the drain tank below the gear cases and deliver through strainers and coolers. Two pumps are sufficient for the normal working, the third being held in reserve. The discharge from one of the coolers is delivered into a gravitation tank, situated in the engine-room hatch, from which oil is supplied to the bearings and thrust blocks. That from the other two is passed into another gravitation tank for supplying oil to the gearing sprayers which direct the oil between the teeth of the gear wheels and pinions. Arrangements are available to by-pass these gravitation tanks and so deliver the oil direct to the bearings and sprayers. The lubricating oil is purified by the use of a De Laval plant.

The propellers are of the built-up type with four manganese bronze blades attached to the cast-steel bosses by Lowmoor iron studs.

Underslung condensers are attached directly to the low-pressure turbines, and the condensate from them is dealt with on the Weir closed-feed system to supply the boilers with de-aerated feed water at high temperature. The plant comprising the system consists of turbo-extractor pumps, air ejectors, turbo-feed pumps, feed heaters and filters. The circulating water is propelled through the condenser tubes by turbine-driven centrifugal pumps. For the auxiliary condenser the circulating pump is driven by an enclosed vertical single-cylinder engine.

Steam is supplied at 220 lb. per square inch pressure by three single-ended and three double-ended boilers of 17 ft. 6 in. diameter. The lengths are 11 ft. 6 in. and 22 ft. 6 in. respectively. The smaller boilers have four Morrison furnaces, while the double-ended ones have eight, and in both types there is a separate combustion chamber for each furnace. Diamond blowers are fitted to them for tube cleaning, and temperature balances are introduced to assist the circulation when raising steam. For the prevention of corrosion Cumberland electrolytic fittings are installed. Oil is burned in the furnaces on the Wallsend-Howden system, the equipment consisting of two large and two small plants. A combination of one large and one small set is sufficient to deal with the whole duty at full power. On each side of the passage between the turbine and the boiler rooms are settling tanks for the fuel oil of sufficient capacity to meet the requirements of 12 hours' continuous running at full power. This oil is drawn from the double-bottom tanks by two oil fuel transfer pumps, either of which may also be used to draw waste oil from the bilges.

A feed pump of the turbine type and two of the direct-acting type are provided. The turbo pump is capable of dealing with the full power demand, and the combination of the two direct-acting units can also meet that duty. Among the other auxiliary plant fitted is a vertical duplex type of bilge pump with gun-metal water ends and also an emergency one driven by gearing and shafting from an electric motor. An electrically-driven rotary pump draws water from the sea and discharges through the sanitary and service mains. A fresh water pump of the duplex type supplies the requirements for washing purposes and a similar one deals with the ship's drinking water. The fresh water supply is passed through filters. Evaporating plant, consisting of two 50-ton sets with automatic feeding system and with brine ejectors, is installed and arranged so that the two component sets may be used singly or worked in series. A distiller capable of dealing with 50 tons every 24 hours is also part of the equipment. Two Royles' calorifiers, one for fresh water and the other for salt water, are installed and have capacities of 12,000 gallons per hour. The workshop in the engine-room is equipped with a lathe, a drilling machine, grinding and other plant. All the propelling machinery and the boilers have been constructed to the requirements of the Board of Trade for passenger certificate and to be classed 100 A1 at Lloyd's under special survey, and to meet the American regulations.

On the completion of this endeavour to meet the demand for a new class of travel service, the Cunard Steamship Company must be congratulated on their enterprise, the successful accomplishment of which was due, in large measure, to their own staff—and particularly to Mr. L. Peskett, the naval architect, and Mr. John Austin, the superintendent engineer.

THE ROYAL SOCIETY SOIRÉE.—In our comments on the exhibits at the Royal Society Soirée we ascribed, on page 625 of our issue of May 18, 1923, the modifications of the Andrew dilatometer, exhibited by the Research Department of Woolwich, to Dr. J. L. Haughton. Dr. Haughton kindly informs us that the chief credit is due to his colleague, Mr. W. T. Griffiths, B.Sc.

THE TELECHRONE TRANSMITTER: ADDENDUM.—We are asked by the makers of the above instrument to point out what is, we hope, clear from the description on page 663, that no separate battery is used to operate the ratchet-gear mechanism embodied in the transmitting instrument. It is the same current that operates both the receiver and the transmitter. We are also asked to state that the number of "impulses" which it is possible to store up at the transmitting end, for subsequent transmission, is the number corresponding to 100 revolutions of the "counter" shaft. There would, of course, be no difficulty in making the "storage capacity" 100,000 or more if desired.

NOTES ON NEW BOOKS.

We have received two German books on graphic statics. The first of these, the "*Statik*," of Dr. Ing. Walther Kaufmann, professor at the Technical High School of Hanover (Berlin: Julius Springer; price 7*s.* 6*d.*), is an octavo volume of 352 pages, with 385 text figures. Forming one of Professor R. Otzen's manuals for structural engineers (Handbibliothek für Bauingenieure) it can be recommended to students and engineers as a clear and systematic text book on the subject. As regards lucidity we are not so certain about the second book, "*Die Methode der Festpunkte zur Berechnung der statisch unbestimmten Konstruktionen*," by Dr. Ing. Ernst Suter, of Baden, Switzerland (Berlin: Julius Springer; price 18*s.* 4*d.*). It is a bigger book, comprising 733 pages, illustrated by 591 text figures, and half of the volume deals with worked-out examples of ferro-concrete structures. The treatment is based upon the "fixed-point" method of graphic solution of the problems of statically-indeterminate structures, as developed by Dr. Suter's teacher, the late Professor W. Ritter, to whom the book is dedicated. Dr. Suter defines "the two fixed points of an elastic beam, the ends of which are not being displaced, as the points which will have zero moment (points of contrary flexure, we should probably say), in case a moment be applied to the one end and there be no external loads; the positions of these points would be independent of any external loading." Most of the examples refer to buildings, bridges, quays, silos, &c., which Dr. Suter constructed when chief engineer to Messrs. Wayss and Freytag, of Neustadt an der Haardt, Württemberg, and they will interest ferro-concrete experts acquainted with the method. Otherwise we fear that Dr. Suter is too full of his subject to make the advantages of his method sufficiently clear to the uninitiated. The absence of an index is to be regretted.

If it be a fact, as has been stated, that automatic telephony involves the employment of more complex apparatus than any other branch of electrical engineering work, we think it would be readily admitted that high-speed printing telegraphy is very little inferior in this respect. The complexity of an automatic telephone exchange arises from the employment of large numbers of similar complicated contrivances, but these, if each be considered separately, appear to be actually simpler than the individual units of apparatus employed in a printing telegraph system, although the number of units required for the latter is, of course, smaller. Nothing, however, is to be gained by a comparison of the two branches of applied science, since the problems involved are entirely distinct, but to anyone wishing to acquire a thorough acquaintance with modern methods of landline and cable telegraphy, we can thoroughly recommend Mr. H. H. Harrison's book on "*Printing Telegraph Systems and Mechanisms*," which forms the latest addition to the Manuals of Telegraph and Telephone Engineering published by Messrs. Longmans, Green and Co. This publication, which is intended for designers, telegraph administration officials, technical telegraphists and students, constitutes a complete text book on the subject, dealing first with the principles upon which telegraph alphabets are based and including a chapter on the general principles of the mechanisms employed in telegraph apparatus. In describing the various systems in use, the author has separated and classified the different types of mechanism employed, giving examples of each in order to enable the reader to analyse any new system and to separate the new ideas from the old. Most modern systems, it need hardly be mentioned, include elements which are mere variations of older apparatus, and it is certainly important for the student to recognise these. Regret is expressed in the preface that the list of British contributors to the art of printing telegraphy is not extensive, although some of the fundamental elements of modern systems originated in this country many years ago. More recently, the author points out, the important developments have taken place in America, and he accounts for this by the fact that, owing to the magnitude of the communication business in that country, it is possible to carry out more extensive systematic research work there. We suggest, however, that the question of private enterprise *versus* State control has a bearing on this matter. In conclusion, a word should be said in praise of the excellent line illustrations, of which there are upwards of 400 in the book. Most of these have been reproduced from the author's own drawings and not, as is frequently the case in text books, from the illustrations in makers' catalogues. This feature greatly enhances the value of the work and is one on which both author and publisher are to be congratulated. The price of the book is 21*s.* net.

While one would hardly expect that a book on the "*Technology of Slate*" would be submitted to a

University—The George Washington University—as a thesis for the degree of doctor of philosophy, Dr. Oliver Bowles' book of this title (The United States Bureau of Mines; price 20 cents), will be welcomed as an addition to the literature on the subject. Mr. Bowles had, subsequent to 1914, presented several reports to the Bureau of Mines on various features of the quarrying industries. Resuming these studies in 1920, he visited 65 slate quarries, and he discusses in his latest book the methods and equipment of slate quarries and the means of reducing the cost of production, improving quality and variety of the product, and of diminishing the proportion of waste. Slate crushing and pulverising are not yet practised by the manufacturers of roofing, structural and electrical slates; of slate granules for coating tar roofing, 268,000 tons were made in 1920, but not out of slate waste, and slate flour might be utilised to a much greater extent than it is at present as filler for asphalt and other road-surface mixtures.

The intricate problems of limiting gauges and tolerances have, especially since the war, received serious attention in Germany as well as in this country. Important papers and books on the subject have been compiled by Schlesinger, Kirner, Klein and Kühn, and a Committee of the Verein Deutscher Ingenieure has been conducting an inquiry under Professor Pfleiderer. The latest contribution to this literature is a volume of 150 pages, illustrated by 144 diagrams, written by Dr. Ing. Otto Kienzle, in conjunction with C. W. Drescher. The title is *Passungssysteme* [Fit systems]. Kienzle dwells in particular upon the choice of limiting gauges in the construction of automobiles, a branch well suited for selective treatment, and Drescher deals with electric machinery. In Germany the controversy is between "unit-bore" system and "unit-shaft" system, corresponding to what is designated over here tolerance on the hole and tolerance on the shaft. In England preference may be said to have turned of late towards keeping the hole standard and arranging for tolerance on the shaft. That preference seems to be shared by the German writers. But they do not consider that the question is settled, and that a general rule can be laid down for the different branches of manufacture; though the unit-shaft system seems generally advisable for mass manufacture, it is not recommended for single articles nor for machinery in general, especially in view of the rapid changes of type in the automobile industry. The volume is published by the Verein Deutscher Ingenieure and obtainable through Messrs. Julius Springer, of Berlin; the price is not stated. The whole subject and its terminology are very complex; we might refer our readers to the article on the principles of limiting gauges which Mr. A. A. Remington contributed to our issue of April 15, 1921.

The late Mr. Bidder could calculate mentally the logarithm of any number to eight figures rather more quickly than the logarithm to seven figures could be extracted from the ordinary tables. Similar powers were possessed by Zerah Colburn, uncle of the founder of ENGINEERING, and by Jaques Inaudi, the unlettered peasant whose arithmetical abilities astonished the Academie des Sciences at Paris some twenty-five or thirty years ago. The average man, however, finds arithmetic tiresome, and the use of a ready reckoner means to him both a saving of time and of mental strain. Attention may accordingly be called to two new ready reckoners recently issued by Messrs. Gall and Inglis. Of these "*The Rapid Decimal Calculator*," published at 1*s.* 6*d.* net, is intended for the use of those who have to price articles in the decimal coinages which are in general use abroad. The tables in the calculator give directly the price of any number of articles when the unit price is fixed. The second volume referred to above is entitled "*The Express Superficial, Cube, and Girthing Reckoner*." It is published at 2*s.* 6*d.* net, and gives areas when the sides of a rectangle are known, or conversely the length of material of a given width to cover a stated area. Amongst the other tables is one giving cubic yards when the area is expressed in square yards and the depth in feet.

The "*Annual Tables of Constants*" and numerical data concerning Chemistry, Physics and Technology, comprised three volumes published in 1910, 1911 and 1912, by an International Association, the secretary of which is Mr. Charles Marie, 9, Rue de Bagneux, Paris 6. The publication of further volumes was interrupted by the war. A fourth volume has now been issued, covering the years 1913 to 1916; it has been compiled by Mr. L. Descroix, of the French Ecole Polytechnique, and a director of *La Revue de Métallurgie*. The publishers for this country are the Cambridge University Press, Fetter-lane, London, E.C. 4. Volume IV is in continuation of the former ones, and contains pages 1,218 to 1,379. It is in two sections—namely, Engineering and Metallurgy. In the engineering section, the tables of mechanical constants apply to timbers, cements, concrete, glass, various materials used in road construction, coke, textiles, paper, &c. They further cover the properties of oils, &c., and also the mechanical constants of turbines, and so forth. Electrical constants and thermal constants of a large number of materials are stated, together with the physical and chemical properties of fuels and fireproof materials. In the metallurgy section are given very numerous equilibrium and other diagrams of a large variety of alloys, accompanied by tabular and other information. Corrosion of different alloys is also dealt with in detail, and mechanical and electrical constants form the subject of numerous references and tables. The book is a useful compendium of engineering data and of information on the constitution of alloys and their various properties. It represents a very large amount of careful work, and Mr. Descroix is to be congratulated on having brought it to a successful issue. The price of the book in paper cover is 210 francs, and bound 250 francs. This Volume IV opens with a preface by Mr. G. K. Burgess, president of the American Society for Testing Materials. The British members of the International Association are stated to be Messrs. A. Egerton, Dr. Glazebrook, Professor Mc.C. Lewis, and Mr. F. E. Smith. We understand that the association is at the present time engaged upon Volume V, for the years 1917 to 1922, and it is to be hoped that the work will then be published regularly, abreast of developments.

While the main problems of piston compressors, being essentially those of the steam engine as affected by special valve arrangements, may fairly be regarded as solved, turbo-compressors remain in a state of active evolution, and there was hence ample justification for a new edition of Professor P. Ostertag's well-known "*Kolben und Turbo-Kompressoren, Theorie und Konstruktion.*" The third edition of this work (Berlin: Julius Springer; price 16*s.* 8*d.*, bound) is like its predecessors divided into three sections, dealing with the principles of technical heat processes, with piston compressors and with turbo-compressors. As professor of engineering at the Polytechnikum of Winterthur, Switzerland, Mr. Ostertag is in close touch with the renowned Swiss firms in this branch, and he devotes a large portion of his volume to the working out of examples and to comments on notable compressors, which are illustrated by 358 good diagrams, very varied as to type and manufacture. He states in his preface that the development of piston compressors for the liquefaction of air had called for particular consideration, but we have not found any special reference to such machines; we may, however, have overlooked them. There is no index. In any case, half of the 301 pages of the volume deal with turbo-compressors. Some diagrams might have been explained more fully, and more information would occasionally be desirable. Describing the rotary compressors with sliding blades of the Wittig and the Reavell types, Professor Ostertag merely indicates the interposition of a revolving cylinder between the rotor and stator, without dwelling on its purpose, the reduction of the wear of the blades. Nor does he appear to discuss the advantages of straight and of curved vanes for turbo-compressors. But a writer has to limit himself, and Mr. Ostertag has certainly made good use of the space at his disposal; yet he should have given more literature references.

We have received three more volumes of the Sammlung Göschen (Berlin and Leipzig), small books of the primer type, intended for students of limited means, sometimes written perhaps in too condensed a style, but not on too "popular" lines. Professor Const. Zietemann, of Chemnitz, has set himself no easy task in his "*Dampfturbinen.* Vol. I. *Theorie.*" The volume by Johannes Körting on "*Heizung und Lüftung*," Vol. I (heating and ventilation, general and calculation), now in its fourth edition, and Professor J. Hermann's *Elektrotechnik*, Vol. IV (generation and distribution of electric energy, second edition), make easier reading. The volumes are offered at the price of 1*s.* each.

SOCIETY OF GLASS TECHNOLOGY.

THE sixty-second meeting of the Society was held in University College, Gower-street, London, W.C. 1, on Wednesday, May 16, the president, Professor W. E. S. Turner, D.Sc., in the chair.

Two sessions were held. At the first session two papers were presented. The first was entitled "*On the Refractive Index Changes in Optical Glass occasioned by Chilling and Tempering*," by Mr. F. Twyman, F.Inst.P., and Mr. F. Simeons, B.Sc., F.Inst.P. In presenting this paper Mr. Simeons defined "chilling" as the rapid cooling from a high temperature, as opposed to the controlled cooling from a medium temperature known as "annealing." Considerable "chilling" could be effected by allowing glass to cool in air from a temperature within or above the annealing range. The process of tempering a metal consisted in the removal of a part of the properties introduced in the preceding operation by heating it to a definite temperature very considerably lower than that attained for "chilling," and allowing it to cool slowly. The term "tempering" was applied to the analogous partial recovery of the properties of glass in the annealed state on heating to a medium temperature. "Annealing temperature" was defined as the temperature at which internal stresses existing in a glass were reduced to one-twentieth of their original amount in 0·26 minute.

It was established that the effect of chilling dense barium crown and borosilicate crown glasses might be the lowering of the refractive index by as much as 0·004 and 0·0013 respectively. This lowering of refractive index was removable by heating to a temperature and for a length of time which had been ascertained in certain cases. It was clear that a want of homogeneity could be produced by moulding, owing to surface chilling, which required for its removal a longer maintenance at the high temperature than would suffice to remove elastic stress from a homogeneous sample.

Mr. V. Stott, B.A., F.Inst.P., followed with a paper entitled "*Notes on Burettes*," in which he gave details of measurements of the amounts of liquids run from burettes under various conditions. His results showed that a burette which empties rapidly, has a very high drainage factor, and the draining from the walls continues over a very long period. In fact, in a 50 c.c. burette emptying in 20 seconds the drainage was not complete in 30 minutes. On the other hand, a burette which has a long emptying time, has a very small drainage, and that drainage is practically complete after a comparatively short time. From these results it was obvious that accurate readings could be obtained much more quickly by using a long emptying time and a short drainage, than by using a short emptying time and a corresponding longer drainage time.

The errors occurring through using a burette calibrated for a certain delivery time with a jet which gave different delivery time were dealt with, and in specified instances it was shown that such errors were too large to be negligible.

At the second session the president referred to the death of Sir Albert J. Hobson, one of the first members of the society. He also intimated that the visit to Paris which had been postponed would take place some time in July.

Two papers were then presented. The first was entitled "*A New Method of Glass-Melting*," by Mr. A. Ferguson.

This method claimed to melt and refine tank bottle glasses with 30 tons of coal to 100 tons of glass, including a margin of 60 per cent. safety. The process consisted of a cone or column of whirling gases at 1,800 deg. C., into the vortex of which batch ground to a 60-mesh standard was dribbled at the rate of 2 lb. per second, the carbon dioxide of the limespar and soda having been first driven off in a preheater so that the work of the furnace was only to raise the temperature from 850 deg. to 1,350 deg. instead of from 20 deg. C. The particles of finely-divided batch exposed to the heat, a surface which was over 6,000 times that of batch "spread on" and the permeation of the particles was 2,000 times easier. All reactions necessary to form glass molecules took place in a gas at least 2,000,000 times less viscous than tank metal, so that affinities could reach each other, collide and react millions of times per second, instead of all the energy of the atom being required for hours to find the waiting affinity lurking somewhere in a tank, and when not encountered resulting in seed, striæ and unequal strain in the glass. None of the data put forward by the author was hypothetical, but such as was in daily use in Europe and America in modern metallurgical practice. All preheating was done by waste heat after the duty of the heat had been carried out. The coal was retorted, the hydrocarbons saved, air and batch preheated and freed from carbon dioxide (which was later converted into carbon monoxide in the producer. The process was entirely automatic from coal and batch bin to warehouse counter. The batch, instantly melted and refined, flowed through a stream line tank to a periphery gatherer in a firehearth.

The second paper was entitled "*Natural Sillimanite as a Glass Refractory*," by Mr. S. English, M.Sc., who gave results of tests which showed that this material possessed properties which made it very valuable to glass makers. Test pieces were made up by mixing 100 parts of sieved sillimanite with 10 parts of finely-ground clay; such a mixture could be made into slabs and pressed into crucibles if care were taken in working it. These slabs and crucibles were examined for the properties which are the chief causes of trouble to glass makers when using ordinary clay refractories, and the results showed: (I) The drying and firing shrinkages of the sillimanite mixture were very much less than the corresponding contractions of pot clay mixtures, in fact, when the sillimanite slabs were completely air dried they showed practically no further shrinkage on firing to 1,400 deg. (II) The porosity of the fired sillimanite slabs was rather less than the porosity of pot clay slabs fired to the same temperature. (III) Sillimanite crucibles were attacked very much less by molten glass at 1,400 deg. to 1,420 deg. C., than were similar sizes of pot clay crucibles. The attack was measured by determining the iron oxide and alumina content of two glasses and remelting each of them for 6 hours at 1,400 deg. to 1,420 deg. in sillimanite and in clay crucibles. The iron oxide and alumina contents were again determined, and comparisons showed that in each case the clay crucibles were attacked three times as rapidly as the sillimanite crucibles.

In the evening the annual dinner of the society was held in the Hotel Cecil. The president was in the chair. The following day a party of some 40 members of the society had the privilege of visiting the new works of Messrs. James Powell and Sons (Whitefriars), Limited, at Harrow.

ROAD MATERIAL PREPARING PLANT.

THE introduction of machinery can be recommended under either or both of two heads. Either it may be adopted in order to cut down labour costs, or with the object of securing a superior product. In these days of unemployment, although we believe that the performance by mechanical means of everything economically possible tends to the general advance of mankind, it is not to be wondered at that there should be a certain amount of timidity in bringing the first argument forward. In the case of a contractor normally nothing less would be expected than that he should use such economical methods as would reduce his tender as much as possible; yet only a short while ago a road contract was deliberately let to a higher bidder, because while the lowest tenderer proposed to employ mechanical appliances the successful contractor tendered for hand labour with a view to decreasing local unemployment. The present position is one of difficulty, but if authorities are going to treat contractors in this way, rightly or wrongly it is hardly to be expected that local officials, except those in the strongest positions, will advance the labour-saving argument. Nevertheless this side merits attention, for though we may be at the moment spending money on manual labour intentionally in preference to paying men for being idle, we shall in course of time return to more normal conditions, when it will only be possible to make the best of our country by doing our work in the most economical manner.

The second head is one under which argument may be advanced even in these abnormal days. In fact, the employment of labour temporarily diverted from other callings adds importance to the fact that a machine will give a regularity of quality which cannot be secured even with manual labour used to the work, and quite impossible when this is unpractised. For this reason the adoption for instance of concrete mixers is to be advocated to a greater degree now than formerly, while the facility with which output can be adjusted to keep the working gangs regularly employed is an added benefit. For these reasons the use of machinery is advantageous in the case of work on a considerable scale, and that this fact is recognised by road authorities is evidenced by the amount of machinery collected on occasions for exhibition at one time and another since the war. In America, as is well known, conditions have tended to develop mechanical appliances in connection with road-making to a greater extent than here—labour has been scarce and its price high—and a greater range of machines is in use in that country. In certain lines, however, the plant adopted in this country is quite as advanced, and in some ways better suited to our work, where we are not so much concerned with the construction of new roads of great length as with the problem of the reconstruction of roads of inadequate width. The new roads actually form only one part of the whole problem of the country and district authorities.

Mention has been made above of the various exhibitions which have been held since the war, of road machinery and municipal plant. These shows, some of which have been very attractive, suffer one disadvantage. The congresses and exhibitions draw together just the type of person to whom the displays are of interest, but while a good deal can be gathered from an inspection of a motionless machine it is not to be expected that the maker's story of its capabilities should be quite as convincing as would be an inspection of it at work on a job. Demonstration therefore of machines at work, such as those organised by the several branches of the Institution of Municipal and County Engineers are particularly helpful. In these the visitors have the opportunity of viewing the machine itself, of getting an idea of the labour it requires, and the scale of gangs it can keep employed, while often data are furnished by the local road officials as to costs, &c. As a rule these lesser demonstrations are not followed up by the Institution itself, but in connection with the Institution's summer meeting at Cardiff in June last year, a demonstration was organised on a rather larger scale, and a report on this was issued some time ago by the Institution. The object of these trials was to afford manufacturers an opportunity of showing what their appliances were capable of, and members and representatives of local authorities the chance to see them at work, so that they might gain useful knowledge of the duty and the comparative efficiency of the appliances. The Cardiff City Council co-operated in the trials by giving facilities for showing the machines at work. The number of entries ran to over 130, though not all appliances were shown at work. In some instances, also, the facilities available did not admit of complete trial and these entries were reserved for supplemental tests. The judges were appointed by the Institution from among engineers and surveyors to councils all over the Kingdom, so that knowledge of a variety of conditions was brought to bear on the trials. No marks were given, but the general characteristics of the appliances were reported on, with special remarks appropriate to the various classes. In all cases the judges considered design, workmanship, strength, stability and durability. Ease in operation were considered under the headings of accessibility, ease of manipulation and operation, labour and power required. Note was also taken of weight, while operating conditions covered involuntary stops during the trials, condition after trials, noise, replacements and so on; general all-round efficiency was also reported upon. With regard to the supplementary remarks peculiar to the several classes, in the road-tarring and gritting class, for instance, note was made of holding capacity, method of distribution, ease and range of adjustment, &c. In concrete mixers the points were output, quality of concrete and clean discharge. In road-tarring appliances time occupied in heating up to working condition, efficiency of heating arrangements, methods of preventing boiling over, nuisance, &c., from which it will be observed that the practical side was kept prominently to the fore. The report further goes into a general description of the appliances and gives their prices, which, however, in these days are, of course, subject to a certain amount of change.

In view of the authoritative character of this report we consider that it would be of interest to deal with a selection of the machines exhibited. We do not propose at this date to give any account of the exhibition itself, nor is it possible for many reasons to deal with all the machines which gave a good account of themselves in the trials. We must confine ourselves to a few of the appliances upon which the judges reported favourably, but are compelled through lack of space to leave untouched many which possessed commendable features of one type or another. The few that we have selected are not only, we believe, fairly representative of what the judges considered good, but, from the reports, may be assumed to be in the front rank of their respective classes.

Dealing first with concrete mixers we illustrate in Figs. 1 to 9 on this and the next pages a machine on which the judges' report was particularly favourable. The example at the trials was a 6-cub.-ft. "Roll" mixer by the Builders and Contractors Plant, Limited, 51, Tothill-street, Westminster. This machine is reported upon as very good as regards design, workmanship, strength, durability, &c., the engine being good also. It is described as "an excellently designed machine, soundly constructed and of ample strength," and very compact. The mixing was carried out in a thoroughly efficient manner. The output of the machine at

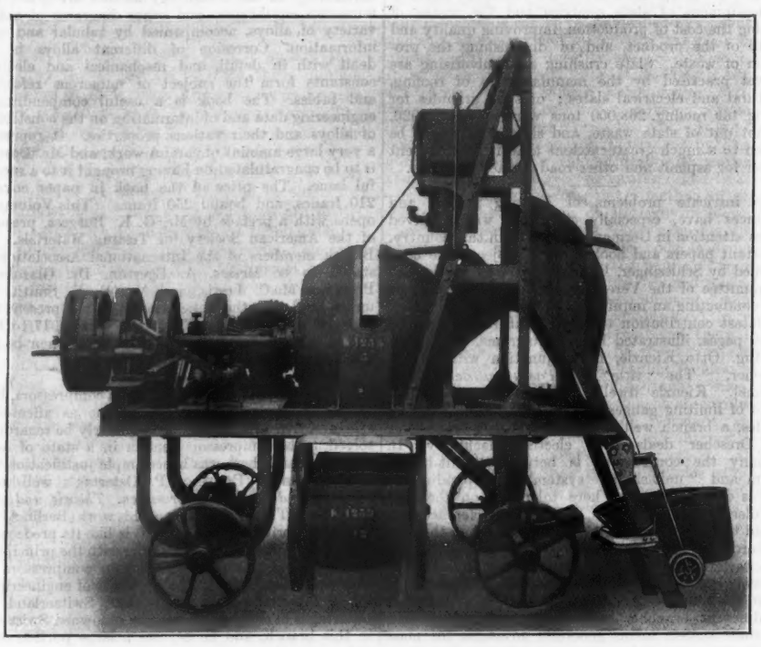


FIG. 1. 6-CUB.-FT. "ROLL" PORTABLE CONCRETE MIXER.

Fig. 2.

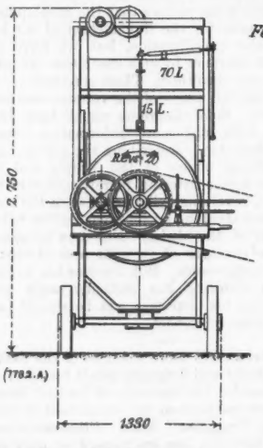


Fig. 3.

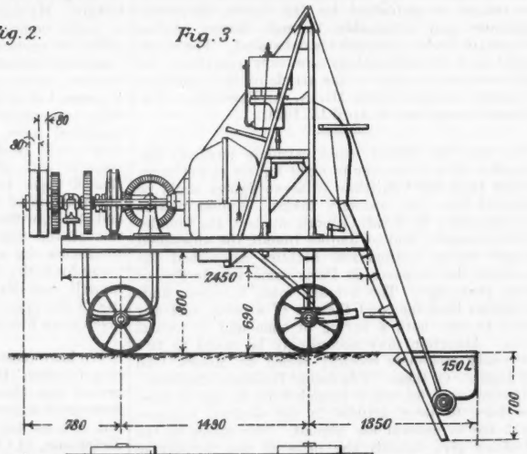
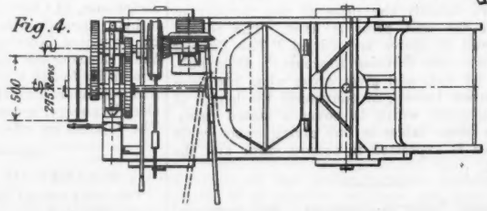


Fig. 4.



Cardiff was about 30 batches per hour, the drum being run at 20 r.p.m. The example shown in our illustrations is belt driven; in the power-driven machine of 6 cub. ft. capacity the 3-h.p. engine is placed above the frame. In some other sizes it is placed below.

Fig. 5.

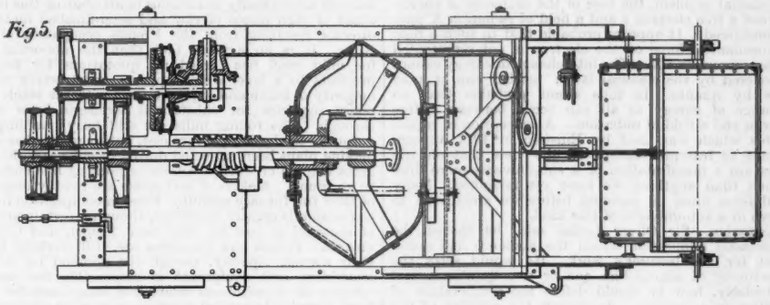


Fig. 6.

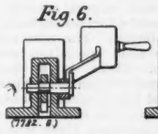


Fig. 7.

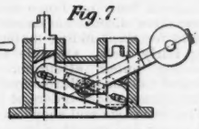


Fig. 8.

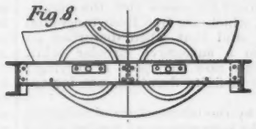


Fig. 9.

The 6 cub. ft. machine has a drum 39 in. in diameter by 24 in., of ¼ in. steel plate, without paddles. The drum is driven through reduction gearing and is arranged for an unique system of discharge. The drum consists of two cupped halves. The half nearest the charging end (the right-hand end in Fig. 5) is carried on a shaft driven from the main gears, while under the charging mouth are carrying rollers (Fig. 8). The mating part is carried by a sleeve which slides lengthwise upon the driving shaft, being driven by the latter by keyway and feather. In the smaller machines to discharge, this half of the drum is moved away from the first by means of a hand-thrown weighted lever. In the larger machines, of which Figs. 5 to 9 are details, the sleeve is cut on the outside with a right and left-handed screw. When mixing, after the proper number of revolutions, an operating lever (Figs. 6 and 7) is moved, and a finger engages with the thread of this screw. The continued revolution of the shaft causes the sleeve with its part of the drum to move lengthwise away from the other part, the batch being discharged between the two. After discharge the operating lever is again moved, and the reverse screw is then engaged by a second finger, and the sliding part moves in again towards the other ready for recharging. The revolution of the drum is continuous the whole time and, all checking being thus avoided, a considerable speeding-up of working is effected, in addition to which there is no pause between mixing and discharge allowing the concrete to settle.

Charging is by a batch hopper which runs on an elevator extending to or below ground level so that the hopper can be filled conveniently from barrows. The hopper is drawn up the elevator by cable taken over the top of an A frame and down to a drum driven by clutch and gears by the engine (or belt pulley). The clutch can be thrown in as the drum closes, so that the batch is discharged without delay down a chute into the drum, through the central mouth. The machine is fitted with two automatic water tanks; one of 15½ gallons acts as a reservoir. Below it is a second of 3½ gallons which acts as an automatic measuring tank to measure off the actual amount required per batch to give the proper consistency. The fuel consumption of the 6 cub. ft. size is reported to be $\frac{1}{10}$ gallon of petrol per hour, the fuel tanks taking 2½ gallons. One attendant is required, and as all controls are centralised it is not necessary for this man to move from one position. The discharge is 2 ft. 6 in. above ground, so that it is possible to run barrows or Decauville trucks below the drum, or the concrete can be led off by chute. The elevator rails are hinged and can be folded for travelling. This size machine with fuel and water, weighs about 35 cwt. Very similar patterns to the one described are made in sizes up to 2¼ cub. yards.

Messrs. Stothert and Pitt, Limited, Orchard-street, Westminster, also submitted a 6 cub. ft. concrete mixer for trial. As might have been expected of work by this firm, this machine was commented upon as being strong and soundly constructed and well designed, satisfactorily mixing the different grades tried. This machine has actually been superseded since the trials by a design embodying improvements so that we do not consider it necessary to detail the features of the machine exhibited at Cardiff. A third machine, of 7 cub. ft. capacity, was shown at work by Messrs. Millars Timber and Trading Company, Limited, Pinner's Hall, Great Winchester-street, E.C. 2. In this case design, workmanship, strength, durability, &c., were designated as very good; and accessibility good; while it was considered satisfactory as regards ease of manipulation and operation. A feature of the drum of this machine is that the sides are flattened in two places with a view to turning the mixture over effectively, split paddles also being provided to break the mix up.

(To be continued.)

THE ROTHERHAM POWER STATION.

On Monday last the Prince of Wales visited the new Rotherham Power Station to put formally into commission the largest turbo-generator so far constructed in this country. The machine in question has a continuous rating of 40,000 k.v.a. at 75 per cent. power factor, or 30,000 kw., the speed being 1,500 r.p.m. This unit, which has been manufactured by the British Thomson-Houston Company, Limited, of Rugby, is the third set to be installed in the new station, the previous ones being a pair of 12,500-kw. Parsons machines built for Melbourne, but diverted to Rotherham by the Government during the war, in order to cope with the need for power in connection with the munition work in that area. The present rated capacity of the station is therefore 55,000 kw., out of an ultimate capacity of 125,000 kw., so that if completed according to present designs, it will rank as one of the largest and most important stations in the country. The new station stands alongside the old, separated only by a roadway, and as the old station contains four turbines aggregating 13,500 kw. capacity, there is at present a total available generating capacity of 68,500 kw.

Coal is brought to the site by rail, the trucks being emptied by a Babcock and Wilcox rotary tippler into a receiving hopper, whence it passes by means of a jigging screen to a 100-ton four-roll breaker. The breaker discharges the crushed coal through an automatic filler, to the buckets of a conveyor capable of dealing with 100 tons per hour. It is raised to a height of 33 ft. and then transported horizontally at this level for a distance of about 320 ft., crossing the canal and the road on its journey. This conveyor terminates opposite the end of the first boiler-house, where it discharges its load into a similar conveyor, nearly at right angles and at a slightly lower level. This second conveyor can either dump into an out-of-door ground-level concrete hopper, with a storage capacity of 3,000 tons, or put the coal direct into the 1,000-ton overhead bunkers of the boiler-house. The conveyor chain on its return passes underneath the outside hopper, and it can therefore take coal from storage when desired and deliver it into the overhead bunkers.

The boiler houses, which run at right angles to the turbine room, are 112 ft. long by 80 ft. wide, each line of boilers being divided into two groups of three, between which the chimney serving the line is erected. There will eventually be three such boiler houses, each with its own external coal store and feeding conveyor. The boilers are of the Babcock and Wilcox marine type, each with its own superheater, economiser and triple chain grate stoker. Each boiler has a heating surface of 8,062 sq. ft., a superheater surface of 2,028 sq. ft., an economiser surface of 5,919 sq. ft. and a grate area of 294 sq. ft. Each such unit will deliver 45,000 lb. of steam per hour at 220 lb. per square inch gauge pressure and at a temperature of 596 deg. F., when water at 100 deg. F. is fed into the economiser. The chimneys are of steel plate construction, 20 ft. diameter at the bottom, tapering to 14 ft. at the top, and rising to a height of 100 ft. from the firing floor level. Each is provided with two Sirocco induced draught fans driven by 150 b.h.p. motors. The basement floor is, as it ought to be, at ground level, and the ashes are dumped from the ash-hoppers into portable crushers, and then taken away by a system of 10-in. suction pipes, into large overhead receivers outside the boiler-house, where they are quenched. Soot and flue dust are also removed by the same means. A 70 b.h.p. motor drives the exhauster serving each line of boilers.

The 12,500-kw. turbo-generators, which, as we have mentioned, were not built for this station, are tandem machines with the low-pressure drum arranged on the double-flow system. They are of the pure reaction type, and together with their condensing plant were constructed by Messrs. C. A. Parsons and Co., Limited. Each delivers, at normal rating, 15,625 k.v.a. of three-phase current at 0·75 power factor, 50 cycles and 6,600 volts, the speed of the machines being 1,500 r.p.m. With 200 lb. gauge pressure at the stop valve, a steam temperature of 588 deg. F., and an absolute condenser pressure of 1·6 in. of mercury, the guaranteed steam consumption at full load is 11·5 lb. per kilowatt-hour. For each turbine there are two condensers, having an aggregate cooling surface of 14,380 sq. ft., and giving the vacuum specified with the suppy of 19,200 gallons per minute of cooling water at a temperature of 70 deg. F. The air pumps are of the three-throw totally-enclosed Edwards type, with hot-well pump at the end, the airpumps being 24 in. diameter by 12 in. stroke and running at 75 r.p.m.

The 30,000-kw. unit mentioned at the outset of this article, is driven by an impulse turbine of the Curtis type, having 14 pressure stages, the first wheel being velocity compounded and thus carrying two rows of blades, while the remaining 13 wheels have a single row of blades each. The largest wheel has an overall diameter of 12 ft., and the weight of the complete turbo-generator is 300 tons. With steam conditions as above, and a vacuum of 1·5 in. absolute, the full load steam consumption is guaranteed as 11·4 lb. per kilowatt-hour, while at the most economical load of 25,000 kw.h., it is 11·1 lb. per kilowatt-hour. The weight of the turbine alone is 145 tons. Owing to the limitations of the railway loading gauge, several of the larger discs had to be removed from the rotor before despatch from the works, and reassembled in position on site. For the same reason the stator of the alternator had also to be transported in parts. Two condensers serve the turbine, either of which can be operated alone when the other is being cleaned. Each condenser has a cooling surface of 22,500 sq. ft., and the two together will maintain a vacuum of 1·5 in. absolute when condensing 277,500 lb. of steam per hour, 36,500 gallons of cooling water at 70 deg. F. being required per minute for this duty.

The condensers were suppled by the Willans Works of the English Electric Company, Limited, who acted as sub-contractors to the British Thomson-Houston Company. Two air pumps of the dry Edwards type, each with three barrels 25 in. diameter by 14 in. stroke, running at 100 r.p.m., are so arranged that either or both can serve either condenser. Vacuum augmentors are also provided, but under normal conditions their services are not required. The air pumps are sealed by a portion of the condensate water, and each is driven by a 60-b.h.p. motor. The main condensate is extracted from the condenser by a pair of Pulsometer centrifugal pumps, which deliver it into the hot-well. Each pump, which is direct-driven by a 23-b.h.p. motor, is capable of dealing with the whole of the condensate. There are four circulating pumps for the station, all delivering into a common main serving the condensers of the three turbines. Each pump is a double impeller Rees Roturbo machine, capable of delivering 19,200 gallons of water per minute, and driven by a 510 b.h.p. motor at 600 r.p.m.

The alternator, which is a three-phase 50-cycle 6,600-volt machine at 1,500 revolutions, is of the totally enclosed air-cooled type of the British Thomson-Houston Company. Without the base-plate bearings it weighs 110 tons, the stator weighing 75 tons and the rotor 35 tons. The exciter at the end weighs 3 tons, thus bringing up the total weight of the revolving parts to 153 tons. The stator of the alternator is split vertically. The rotor is designed for a critical speed of about 1,000 r.p.m., which is well below the running speed. To permit the machine passing through its critical speed without undue vibration the shaft journal at the exciter end is carried in a special bearing which permits a small radial play between friction collars. This type of bearing has proved highly successful in practice, and has been adopted as standard by the company.

The new Rotherham station has been constructed to the designs of Mr. Edward Cross, engineer and general manager of the Corporation Electricity Supply Department, the foundation work being carried out by the Rotherham Corporation. Messrs. Babcock and Wilcox, Limited, were awarded the contract for the main buildings, boilers and boiler-house equipment, the structural steel work being carried out by Messrs.

Heenan and Froude, Limited, as sub-contractors. In addition to supplying the 30,000-kw. turbo-generating unit which has now been put into commission, the British Thomson-Houston Company, Limited, of Rugby, also supplied the whole of the switch gear and auxiliary electrical equipment.

PHYSICAL SOCIETY OF LONDON.

AT the meeting of the Physical Society of London, held on May 11, at the Imperial College of Science, Mr. Alexander Russell, M.A., D.Sc., in the chair, Sir William Bragg, F.R.S., chairman of the Duddell Memorial Committee, handed over to the president of the Physical Society a copy of the Duddell Memorial Medal, together with the dies and a certificate for the unexpended balance of the memorial fund. In the course of his remarks Sir William Bragg said that the committee had been formed in response to a widely felt wish that the work of this distinguished scientist should be commemorated in a suitable manner. A sum of no less than 700*l.* had been subscribed, thanks in the main to the energy of Mr. R. S. Whipple, secretary to the committee. As regards the design of the medal, very great pains had been taken to ensure that it should be worthy of the memory of the dead and of the art of the nation to which he belonged. The work had been entrusted to Mrs. Mary Gillick, and the committee felt that their choice had been very fully justified by the result. Mrs. Gillick had devoted immense trouble and care to her task, and the medal she had produced was one of which the society might be proud.

Photographic slides of the medal were exhibited. On the obverse is a miniature of Mr. Duddell, and on the reverse a figure symbolical of Science examining the world as she finds it, with legends "The Physical Society of London" and "Rerum Naturam Expandere."

Dr. Alexander Russell, president, in accepting the medal on behalf of the society, said that he did so with gratitude to all who had combined to make this memorial possible, and particularly to Sir William Bragg and Mr. R. S. Whipple, whose initiative had set the undertaking on foot, while their perseverance had carried it to such a successful issue. He had been associated with Mr. Duddell at the City and Guilds Technical College and in other connections. He had always marvelled at the encyclopædic character of Mr. Duddell's technical knowledge, which, coupled with his mechanical skill and inventive ingenuity, had enabled him to make so many contributions of permanent importance to the progress of science and of industry. He had been treasurer, member of council, and vice-president of the Physical Society, and president of the Institute of Electrical Engineers.

Sir Richard Glazebrook said that it gave him great pleasure to express his warm and intense admiration for Mr. Duddell. The latter had been a cordial helper of the National Physical Laboratory, especially during the war, and had always been ready to give generously from his great store of knowledge and of scientific resource. His memory would be kept alive not only by his own work, but by the admirable medal which had been designed; and it was to be hoped that the latter would encourage others to follow his example and to engage in the field of scientific enterprise in which Duddell had been such a prominent worker.

Terms of Awards of the Duddell Medal—The following resolution was adopted by the council on May 11, 1923: "That the 400*l.* war loan 5 per cent. 1929–47 inscribed stock be accepted in trust from the Duddell Memorial Fund Committee and that the income therefrom be expended in accordance with the following regulation: A bronze medal shall be awarded by the council not more frequently than once a year to persons who have contributed to the advancement of knowledge by the invention or design of scientific instruments or by the discovery of materials used in their construction. The award shall be made without restriction as to nationality or fellowship of the society. A parchment certificate of award and a sum of money may accompany the medal. Should more than one person be connected with the invention or discovery for which the award is made, the council may at its discretion present more than one medal and apportion the money accordingly. The terms of awards shall not be varied except by special resolution passed by the society at a general meeting and confirmed at a subsequent meeting."

The Eighth Guthrie Lecture was delivered by Mr. J. H. Jeans, D.Sc., LL.D., F.R.S., who took as his subject "*The Present Position of the Radiation Problem.*" Of this lecture the following is an abstract: Since about 1900 it has been obvious that classical dynamics are in conflict with experience in certain respects, and particularly with respect to the radiation problem. The observed discrepancies suggest that the laws of Nature must in some way be discontinuous. To explain the observed nature of black-body radiation Planck propounded the quantum theory; in the hands of Bohr it soon became apparent that the quantum theory contained also the clue to the line spectrum. Hence arose hopes of rapid development which should explain the whole of the radiation problem and reduce molecular physics to order. Progress, however, has been slow and difficult, and what progress there has been is concerned with the structure of matter and not with radiation. Einstein's hypothesis of light quanta appeared to possess obvious advantages, but has had to give way before the destructive criticism of Lorentz and others, and the direct experimental test of G. I. Taylor.

The different methods of interchange of energy between matter and ether or radiation may be classified as sub-atomic, atomic and mass transfers. Typical of the first is the emission or absorption of radiation by a Bohr atom; of the second the motion constituting heat in a solid; and of the third the transmission of momentum occurring when a beam of radiation falls upon the surface of a perfect reflector. An examination of these leads to a constant view, namely, that physical and chemical transfers take place by quanta, while mechanical transfers take place according to the classical laws.

As an example of the application of general principles to a special problem, the case of the exchange of energy between a free electron e and a field of radiation X may be considered. It appears probable that in such a field the mechanical force on the electron is not represented by the expression e X. The interchange of energy cannot be covered by the classical laws; neither can it take place by quanta. It thus seems probable that no exchange of energy at all can occur between a free electron and a field of radiation. A conception in regard to this which was used by Einstein in 1917 appears difficult to interpret except on the view that electric forces are a manifestation of a sub-universe more fine-grained than anything we have yet imagined. Many possibilities must be explored before we are driven to believe in a sub-universe of this kind.

Discussion.—Sir Oliver Lodge said he shared the enthusiastic admiration which the audience had manifested for the lecturer's work. He would seize the opportunity of asking him one or two questions, and particularly, how he would define the temperature of radiation in a vacuum. As regards the stability of the orbits in an atom, how would Dr. Jeans view the suggestion that circular orbits, which are free from tangential acceleration are stable; and that when disturbed an electron spirals down to a successive circular orbit, radiation taking place since now the speed is varying? Such a change would be of finite duration, not instantaneous.

Dr. Jeans replied that by the temperature of radiation in a vacuum he meant the temperature of matter which could be in equilibrium with space containing that radiation. The word stability denoted a conception that had been left behind by the quantum theory, which only thinks of states. The notion of asymptotic spirals seems open to the fatal objection that each circular orbit must be quitted determinately for the nearest orbit, whereas in reality each orbit may be quitted for any one of a number of possible orbits. The passage from orbit to orbit may be supposed to occupy a time equal to some 1,000,000 light periods.

A hearty vote of thanks to the lecturer was moved by Dr. C. Chree, seconded by the Lord Rayleigh, and carried by acclamation.

PADUA SAMPLE FAIR.—It is announced that a number of foreign countries are to exhibit at the annual International Sample Fair to take place in Padua (near Venice) in the first half of June. This fair is said to be one of the oldest, if not the oldest, held in Europe. The London office of the Italian State Railways and Tourist Department reports that special reduced rate tickets will be issued to Padua during the period of the fair.

THE OPTICAL SOCIETY.—The society announce that by courtesy of the Astronomer Royal, a visit has been arranged to the Royal Observatory, Greenwich, on Saturday, June 9, at 3 p.m. Fellows and members desirous of availing themselves of the opportunity of visiting the Observatory on this date are requested to send their names to the Honorary (Business) Secretary of the Society at the Imperial College of Science and Technology, South Kensington, S.W. 7.

THE EARLY HISTORY OF THE TELESCOPE.—At a meeting of the Optical Society held at the Imperial College on Thursday, May 24, 1923, Mr. R. S. Whipple, vice-president, in the chair, the sixth of the series of lectures on the evolution and development of optical instruments was delivered by Mr. David Baxandall, A.R.C.Sc., the subject being "Telescopes before the Early Part of the Nineteenth Century." The period from the time of Roger Bacon (died 1292) to the beginning of the seventeenth century was dealt with at some length, extracts from the writings of Recorde (1551), Digges (1570), Dee (1570) being exhibited on the screen. Particular attention was directed to William Bourne's description (1585) of a 12-in. perspective glass of about 15 ft. focal length, which gave telescopic vision and magnified distant objects about 20 times. The invention of the telescope with concave eye lens by Hans Lippershey in 1608 was next dealt with, the positions of Lippershey's and Janseri's shops in Middleburg being shown. Pictures of Galileo's Tribune and of his telescopes at Florence were shown, also of the telescopes of Schenier, Hevelius, Huygens and Campani. William Gascoigne's description of the way he arrived at the invention of telescopic sights was quoted. The invention of the Gregorian and Newtonian reflecting telescopes was next referred to, and followed up later by a description of Hadley's reflector. The work of Chester Moor Hall, the researches and work of John Dollond and Peter Dollond on the development of the achromatic lens came next, followed by references to the work of Herschel, Ramsden, Tulley, Guinand and Fraunhofer. The objects from the Science Museum which were exhibited at the lecture included an early Italian telescope, and object-glasses or telescopes by Reeves, Howe, Marshall, Scarlett, Cuff, Mann, Ayscough, Martin, Short, Dollond, Herschel, Nairne, Ramsden, Tulley, Fraunhofer and other telescope makers from the latter part of the seventeenth until the early part of the nineteenth century; the original glass negative made by Sir John Herschel in 1839, William Herschel's polishing machine, and the 7-ft. reflector with which he discovered the planet Uranus. A considerable number of these examples were from Mr. Thomas H. Court's fine collection in the Museum.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Mixed conditions prevail throughout the heavy industries, with here and there a downward tendency. The promise held out in the earlier months of the year has not materialised. The leading engineering masters are virtually unanimous in attributing this to the effect of high prices of raw and semi-finished materials directly resulting from the French occupation of the Ruhr. It is an evident fact that the abnormal call for mild steel has forced up quotations for finished products to a level which appears unattractive to the majority of home and export buyers with the result that many inquiries for substantial tonnages have fallen through. The rolling mills are still busy handling the output of the basic steel furnaces, but so greatly has steel-making plant been extended during recent years that the gross volume of work available is nothing like sufficient to go round. Makers of soft steels are readily disposing of their full furnace output. Foreign competition in this connection is greatly restricted, though a certain amount of material is now on offer from French and German makers. Forges and foundries are still working below their normal capacity, though the demand for mining machinery and equipment is responsible for the re-opening of departments which for many months have been closed. Improved conditions in railway steel are maintained both on home and export account. The boilermakers' dispute has caused a further setback in the demand for shipbuilding materials. The wire mills are doing fairly well. Crucible steel specialties are only attracting minor attention. There is a distinctly improved call for malleable iron for engineering purposes. In the lighter trades orders of fair magnitude have been received for picks and shovels for use in connection with road repair and construction schemes, there is a steady call for electrical equipment, and engineers' small tools are rather more active. The demand for files is slowly improving, but much of the business most recently booked is at a thinly remunerative price.

South Yorkshire Coal Trade.—There is a certain amount of pressure on colliery output, but this is due to deliveries getting into arrear through the holiday stoppage rather than to an expansion in current business. Exports of coke are distinctly lower, though there is still a fairly strong demand for best steams for shipment. Home users are taking full contract tonnages, and railways are steadily augmenting reserves. Supplies of cobbles and nuts are more abundant without there being any alteration in official rates. Slacks continue a steady market. House coal is depressed even for this season of the year. Quotations:—Best branch handpicked, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 25*s.* 6*d.* to 27*s.* 6*d.*; Derbyshire best house, 23*s.* to 24*s.* 6*d.*; Derbyshire best large nuts, 20*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best small nuts, 18*s.* to 21*s.*; Yorkshire hards, 22*s.* to 24*s.*; Derbyshire hards, 21*s.* to 24*s.*; rough slacks, 12*s.* to 14*s.*; nutty slacks, 10*s.* 6*d.* to 12*s.* 6*d.*; smalls, 7*s.* to 9*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The market just now is inanimate, but a continued under-current of optimism encourages the hope that stagnation may not be of long duration. Makers have a fair amount of work on hand, but are anxious to secure orders to follow on contracts running out. Absence of buying is weakening prices. The feeling however prevails that so soon as quotations become stabilised, a steady flow of trade will be experienced. Extreme scarcity of No. I enables producers to keep the market figure for that quality at 130*s.* Siliceous iron is put at 125*s.* No. 3 has been sold at 120*s.*, and that may be given as the general quotation, though for small parcels rather more has to be paid. Foundry 4 is 117*s.* 6*d.*, and No. 4 forge is 115*s.* Little of the last-named quality is on offer, most makers using the output for their steel works. All the foregoing quotations are f.o.t. makers' works or f.o.b. Tees.

Hematite.—Little new is ascertainable concerning the hematite branch. Production has been somewhat curtailed by a furnace going amiss, but supply is quite ample to needs. Fairly good inquiries are reported. Nos. 1, 2 and 3 stand at 122*s.* 6*d.*, and No. 1 is 123*s.* to 123*s.* 6*d.*

Foreign Ore.—Consumers of imported ore are still off the market, being fairly well bought, and having good working stocks, but sellers are inclined to take a rather more hopeful view of the outlook, and ask 25*s.* c.i.f. Tees for best rubio.

Blast-Furnace Coke.—Furnace coke keeps scarce. For renewal of contracts local regular customers have to pay 44*s.* 6*d.* delivered.

Manufactured Iron and Steel.—There are not many inquiries circulating for finished iron and steel, but order books in several branches are fairly good, and manufacturers are still most reluctant to lower quotations. Billets are very weak, due to the cheap foreign semi-finished steel that is being offered freely here, but other prices are well upheld. Among the principal market quotations are:—Common iron bars, 12*l.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 10*l.*; steel billets (medium), 10*l.* 10*s.*; steel billets (hard), 10*l.* 15*s.*; steel boiler plates, 14*l.*; steel ship, bridge and tank plates, 10*l.* 10*s.*; steel angles, 10*l.*; steel joists, 10*l.*; heavy sections of steel rails, 10*l.* 10*s.*; fish plates, 14*l.* 10*s.*; black sheets, 14*l.* 10*s.*; and galvanised corrugated sheets (24-in. gauge, in bundles), 19*l.* 10*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The conditions in the Scottish steel trade have not altered over the week, and there is no change to note. Week by week sees orders getting cleared up with little coming in to replenish the books. Buyers are still holding back partly because of the high prices ruling and partly because of the uncertainty of general business, but another factor which cannot be overlooked is the cheap prices being quoted from the Continent. These apply chiefly to sectional material and are very tempting to home consumers, but the old trouble about deliveries is again responsible for dealings being somewhat limited so far. A feeling prevails here that if local prices were reduced a greater volume of business might result, but on the other hand producers cannot see their way to cut prices meantime on account of the high on-cost charges now ruling. The black sheet makers are keeping fairly busy, but there is a great scarcity of home orders. The following are the current prices:—Boiler plates, 13*l.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—There has been little increase in the booking of fresh business by the bar-iron makers of the West of Scotland, and new lots on offer do not make up a heavy tonnage. The orders on hand are keeping plant going at present, but the outlook is not very bright. The steel re-rolling side of the business is still fairly good. Prices are easier, as the Scottish bar-iron makers made a reduction in home quotations of 10*s.* per ton this week in the hope of inducing more business. The price of "Crown" bars is now 12*l.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—Trade in Scottish pig-iron keeps fairly steady, but the level is not very high at the moment as both home and export buyers are purchasing very sparingly. The general inquiry is also very poor, and the prospects are not bright. Current quotations are as follow:—Hematite, 6*l.* 7*s.* 6*d.* per ton, delivered at the steel works; foundry iron, No. 1, 6*l.* 1*s.* 3*d.* per ton, and No. 3, 5*l.* 16*s.* 3*d.* per ton, both on trucks at makers' works.

Scottish Pig-Iron Shipments.—The export of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, May 26, was 1,380 tons. Of that total 1,310 tons went foreign and 70 tons coastwise. For the corresponding week of last year the figures were 1,855 tons foreign and 46 tons coastwise, making a total of 1,901 tons.

Shipbuilding.—The Ailsa Shipbuilding Company, Limited, of Troon and Ayr, have secured an order from the Clyde Lighthouses Trustees for a new lighthouse steamer. The new vessel will replace the present twin-screw steamer Torch which is on lighthouse duty, and which was built at Port Glasgow forty-one years ago.

Steelworkers Suspended.—The quietness in the steel trade has caused much unemployment during recent months and conditions are not improving. Last week a large number of steelworkers were suspended in the Motherwell district owing to scarcity of work, and this week between 3,000 and 4,000 men have been signed on at the local labour bureaus.

PERSONAL.—Mr. Sidney Simpson, who formerly was on the Yorkshire Electric Power Company's staff, 1908–19, and has been (since 1919) associated with Mr. J. E. Schofield, Bradford, and Messrs. Mark Shaw and Sons, Limited, Huddersfield, informs us that he has commenced practice on his own account as consulting engineer in connection with the steam, heating, power and lighting, &c., with offices at 9, Market-street, Bradford.

THE TRAINING OF NAVAL ENGINEER OFFICERS.—The Admiralty has announced the appointment of Engineer-Commander James Ashton, D.S.O., to the staff of the Royal Naval Engineering College at Keyham. Provision was made in the recent Navy Estimates for increasing the staff of officers at the college from 9 to 16, and the total of all ratings and grades from 91 to 135. In the older of the two schemes at present in operation at Keyham, the course of training for engineer-lieutenants extends for twelve months, the officers joining after a six months' preliminary course at Greenwich. The new scheme, which came into operation last year, provides for three years and eight months' training at Keyham, to which college midshipmen are appointed immediately on leaving the training ship Thunderer.

BRITISH ENGINEERING STANDARDS ASSOCIATION.—The Association has recently issued a specification, No. 186—1923, for cast-iron and enamelled cast-iron steam-jacketted pans, the designs for which were prepared by the Joint Committee of British Chemical Manufacturers and the British Chemical Plant Manufacturers' Association. Tables are included in the specification which give the dimensions for pans of both shallow and deep type, the capacity of the former ranging from 26 gallons to 100 gallons and of the latter from 10 gallons to 200 gallons. The tables are accompanied by complete key diagrams on which the dimensions are given. Equivalent capacities in litres are also given for the convenience of those using metric units. The tables are preceded by clauses dealing, among other matters, with enamelling, working presures, and the tests to be applied to the complete pan ready for service. Copies of the specification may be obtained from the Secretary at the Offices of the British Engineering Standards Association, 28, Victoria-street, London, S.W. 1, the price being 1*s.* 2*d.* post free.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—For the moment prices have developed an easier feeling. It is, however, still difficult to secure supplies, for the colliery companies in the majority of cases are in an exceptionally strong position, being well booked up with contract commitments. On the other hand, merchants holding contract supplies bought at much below current values are discounting colliery prices to the extent of 2*s.* per ton. At the same time the demand has slackened off in consequence of the disorganisation on the Continent. Colliery owners, however, continue to demand from 40*s.* to 42*s.* 6*d.* for best Admiralty large coal, 40*s.* for seconds and Monmouthshire large, and 37*s.* 6*d.* for ordinary qualities, while best bunker smalls ruled from 30*s.* to 32*s.* 6*d.*, with seconds round 27*s.* 6*d.* There is a French inquiry in the market for up to 120,000 tons of coking smalls, delivery in equal monthly quantities over the second half of the year, and the Swedish State Railways also want offers for 90,000 tons of Welsh or North-Country large coals. Anthracite coals are, however, very scarce and firm, with machine-made cobbles up to 60*s.*, French nuts 57*s.* 6*d.* and stove nuts 55*s.* Exports of coal as cargo last week were reduced as a result of the Whitsun holidays. In all, 441,960 tons were shipped as cargo, of which 159,790 tons went to France, 58,422 tons to Italy, 44,170 tons to South America, 24,370 tons to Spain, 30,050 tons to Portugal, 8,180 tons to Greece, 24,290 tons to British coaling depots, 10,510 tons to the United States, 9,030 tons to Canada, 16,955 tons to Belgium, 10, 960 tons to Holland, 13,340 tons to Germany, and 31,840 tons to other countries.

Iron and Steel Trades.—It was decided at a meeting of the Welsh tin-plate manufacturers yesterday to continue the price stabilisation scheme for a further three months. Little concern is being paid to a threatened strike of the steel works locomotive men, because the notices which are due to expire on Saturday are unofficial and the men have been told by their leaders that any change in rates and conditions must come before the Joint Board. Exports of tin plates and terne plates last week amounted to 6,800 tons, compared with 10,450 tons in the previous week, black plates and sheets to 1,397 tons, against 6,490 tons; galvanised sheets to 316 tons, against 2,670 tons; and other iron and steel goods to 1,238 tons, against 2,900 tons.

INSTITUTION OF STRUCTURAL ENGINEERS.—The names of the members of council who come into office on September 1 were announced at a recent special general meeting of the Institution. The president is Major James Petrie. The address of the Institution is Denison House, 296, Vauxhall Bridge-road, S.W. 1.

BUSINESS WITH AUSTRALIA.—Mr. Alexander Simpson, H.M.'s Trade Commissioner at Sydney, now on a visit to the United Kingdom, will be pleased to interview firms interested in trade with Australia, particularly New South Wales, at the Department of Overseas Trade from June 4 to 9 inclusive. Applications for interviews should be addressed without delay to the Comptroller-General, Department of Overseas Trade, 35, Old Queen-street, London, S.W. 1, reference number 4757 T.G.

THE AIR MINISTRY AND RACING AIRCRAFT.—The Air Ministry has announced that, with a view to encouraging the entry of British aircraft in international air races, the Air Council have undertaken to purchase the winning aircraft in both the Aerial Derby and the Schneider Cup races, provided that the aircraft is of British design, construction, and ownership, and has not previously won either race. The Air Council considers that the production of aircraft capable of winning these events represents a definite advance in design, but experiments will be undertaken after the purchase to develop the aircraft as far as possibe from the research and military points of view. The offer applies not only to the Aerial Derby, which will be held this year at Hendon on August 6, and to the Schneider Cup race, which will take place at Cowes on September 27 and 28, but also to the races to be held in future years until further notice. Both races are of an international character, and the former is open to any type of land machine or amphibian, while the latter is open to seaplanes and amphibians only. The sum to be paid for any particular aircraft, exclusive of the engine, will not exceed 3,000*l.*

NORTON AND GREGORY ANNUAL SCHOLARSHIPS IN ENGINEERING.—With reference to our paragraph on page 71 *ante*, Messrs. Norton and Gregory, Limited, announce that the following scholarships have been awarded for the current year: (1) Rollo Houghton, Bradfield College, Berks.: honorary scholarship of 25*l.* per annum, tenable for three years at Cambridge University. (2) Denis Moody, Central Foundation Boys' School, London: 75*l.* per annum, tenable for three years at University College, University of London. (3) Frederick Rapley, Sunderland Bede Collegiate Boys' School: 50*l.* per annum, tenable for three years at Cambridge University. The essential consideration in making these awards being the financial needs of the candidates, the Scholarship Committee, in allocating the above amounts, took into consideration the fact that Rollo Houghton had already secured an Entrance scholarship to Cambridge University and a Kitchener Memorial scholarship, tenable for three years at that University. The total number of candidates who entered for the examinations was 266, out of whom the committee invited 187 to sit in London and five provincial towns.

NOTICES OF MEETINGS.

THE ROYAL SOCIETY OF ARTS: DOMINIONS AND COLONIES SECTION.—Tuesday, June 5, at 4.30 p.m. "The Economic Conference and the Colonies," by Sir Edward Davson. His Grace the Duke of Devonshire, K.G., G.C.M.G., G.C.V.O., P.C., Secretary of State for the Colonies, will preside.

THE INSTITUTION OF ELECTRICAL ENGINEERS: WIRELESS SECTION MEETING.—Wednesday, June 6, at 6 p.m. "Wireless Direction-Finding in Steel Ships," by Mr. C. F. Horton.

THE INSTITUTION OF CHEMICAL ENGINEERS.—Friday, June 8, at 5 p.m., at the Engineers' Club, 39, Coventry-street, W. 1. Annual Corporate Meeting. Paper on "Industrial Oxygen," by Mr. T. C. Finlayson, B.Sc. At 8 p.m., Informal Dinner.

THE OPTICAL SOCIETY.—Thursday, June 14, at 7.30 p.m., at the Imperial College, Imperial Institute-road, South Kensington, S.W. 7. Papers to be read and discussed: "Levels and Level Bubbles," by Mr. S. G. Starling, A.R.C.Sc., B.Sc., F.Inst.P.; "A New Form of Balloon Theodolite," by Mr. T. F. Connolly, M.Sc.; "The Primary and Secondary Image Curves formed by a Thin Achromatic Object Glass with the Object Plane at Infinity," by Mr. E. Wilfred Taylor.

THE INSTITUTION OF QUARRY MANAGERS.—This Institution will hold its annual conference at Llandudno, North Wales, on June 28, 29 and 30.

PLATE GIRDER SPANS FOR NEW ZEALAND.—Plans and specifications have been received at the Department of Overseas Trade from H.M. Trade Commissioner, Wellington, relative to a call for tenders by the Public Works Department, Wellington, for 13 plate girder spans, of 20 ft. to 55 ft., for the Auroa section of the Opunaku Branch Railway. Tenders are also invited for 12 plate girder spans of 30 ft. and 40 ft. for the Napier Gisborne Railway, Tutira section. The latest date for the receipt of tenders in Wellington is in each case July 3, 1923. The plans and the specifications are available for inspection by British firms at the Department of Overseas Trade, Room 50.

RADIOTELEGRAPHY AND TELEPHONY ON THE "GENERAL SAN MARTIN."—The passenger steamer General San Martin, of the Hugo-Stinnes line, which left Hamburg in April for South American ports, is provided with a quencher-spark radiotelegraphy outfit, and further with valves and apparatus for both radiotelegraphy and radiotelephony. Arrangements have been made with the Norddeich station to conduct range experiments. The transmitter of the valve set works with wave-lengths ranging from 500 m. up to 3,000 m. There are two valves, each taking 250 watts, and a smaller valve is inserted in the grid circuit. The anode current for the whole set is supplied by an alternating generator driven by a direct-current motor; the alternating currents are rectified by two kenotron tubes, i.e., plain valves without grids.

TESTING EMERGENCY GOVERNORS IN SERVICE.—In general the only way of testing emergency governors is to run the turbine up beyond its normal speed, noting on the tachometer the revolutions per minute at which the valves are tripped. In view of the somewhat numerous catastrophes due to burst impulse wheels in America, this plan is somewhat out of favour there with the operating staffs of the power stations. To meet this condition of affairs the Westinghouse Company, although, so far as we know, no serious accidents have been reported with their pattern of turbine, have devised a simple method of testing the reliability of an emergency governor whilst the turbine is running at or below its normal speed of revolution. The standard pattern of emergency governor consists of a plug sliding in a recess bored transversely through the turbine shaft. Matters are so arranged that the centre of gravity of the plug is not in the centre of the shaft. The centrifugal force, therefore, impels the plug outwards, and this tendency is resisted by a spring, the strength of which is adjusted so that it yields to the centrifugal force when the speed exceeds the designed limit. The end of the plug then protrudes from the shaft and strikes a trigger which in its turn opens a valve on the oil supply service, and brings into action a relay or equivalent mechanism by which the steam valves are closed. The Westinghouse Company provide means by which oil can be introduced below the plug in the shaft and the pressure of this oil aids the centrifugal force to overcome the resistance of the spring, so that by using sufficient pressure the plug can be made to protrude and trip the trigger even if the turbine be running at its normal speed. The pressure required to bring the governor into action tests the state of the latter. If there be any tendency for the plug to stick, the pressure required will be higher than normal, thus showing that the governor requires attention. To introduce the oil below the plug, oilways are bored in the shaft and terminate in a hole concentric with the shaft centre. Opposite this hole and concentric with it, there is a square-ended tube which normally rests clear of the shaft, but can be pressed in contact with it. When this is done the oilways in the shaft are brought into communication with piping connected through a valve with the general oil service of the turbine. This connecting piping is provided with a pressure gauge, and in making a test the valve is slowly opened, and the gauge pressure noted at which the trigger is tripped.

THE PRESCOT WORKS OF THE BRITISH INSULATED AND HELSBY CABLES, LIMITED.

(*For Description, see Page* 675.)

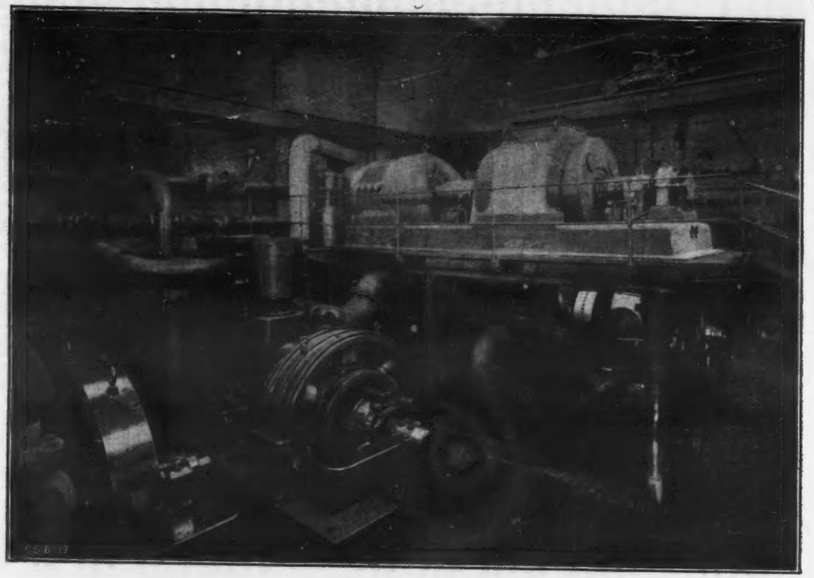


FIG. 2. ELECTRIC GENERATING STATION.

FIG. 4. TELEPHONE CABLE SHOP.

FIG. 3. BATES AND PEARD BRIGHT ANNEALING FURNACE.

FIG. 5. CABLE ARMOURING SHOP.

FIG. 3. CABLE ARMOURING SHOP.

TURBINES OF THE CUNARD TWIN-SCREW STEAMER "FRANCONIA."

CONSTRUCTED BY MESSRS. JOHN BROWN AND CO., LIMITED, ENGINEERS AND SHIPBUILDERS, CLYDEBANK.

(*For Description, see Page* 680.)

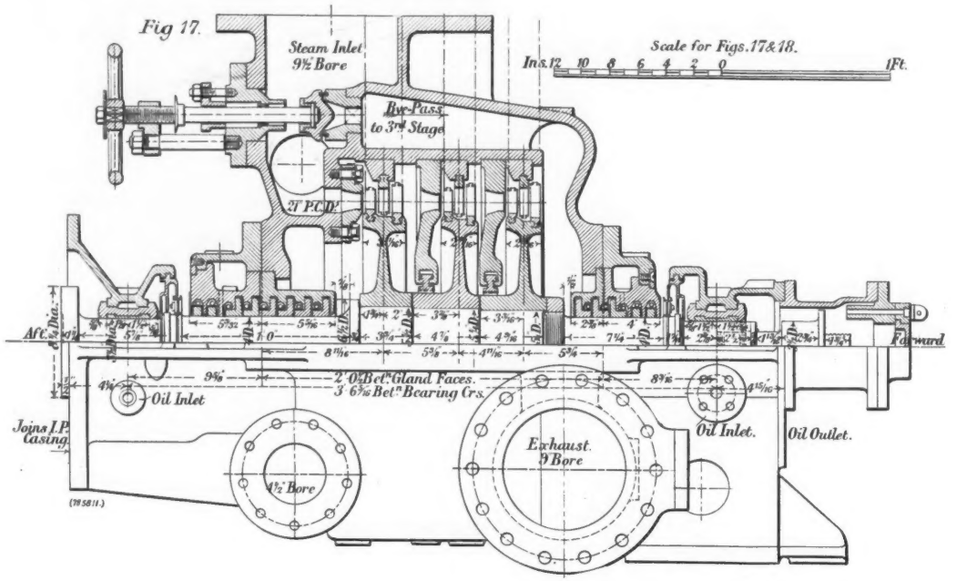


FIG. 17. HIGH-PRESSURE AHEAD TURBINE.

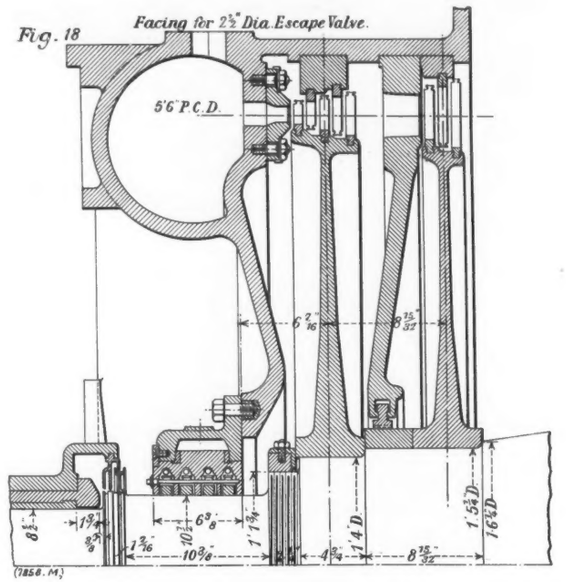
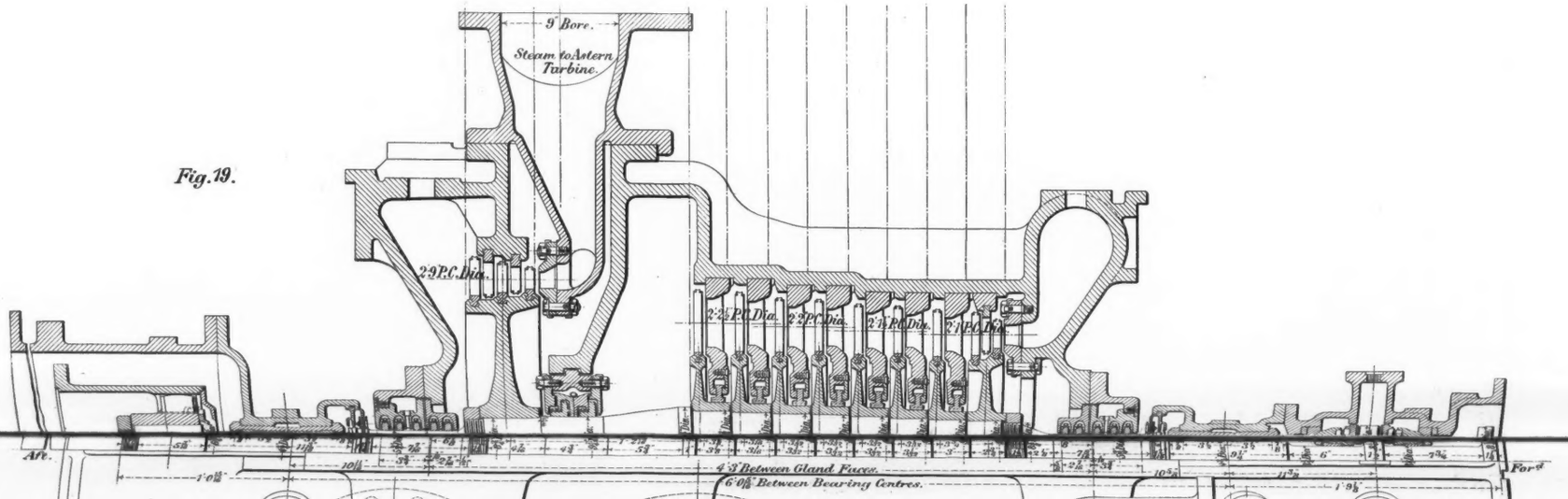


FIG. 18. LOW-PRESSURE ASTERN TURBINE.



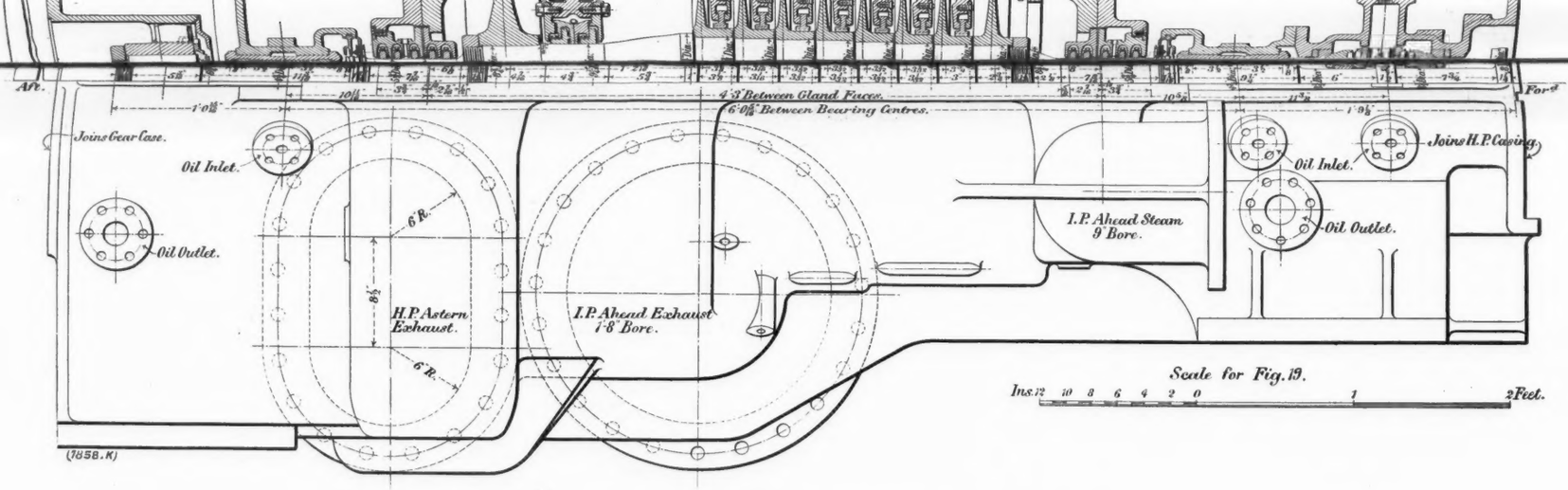


FIG. 19. INTERMEDIATE-PRESSURE AHEAD AND HIGH-PRESSURE ASTERN TURBINES.

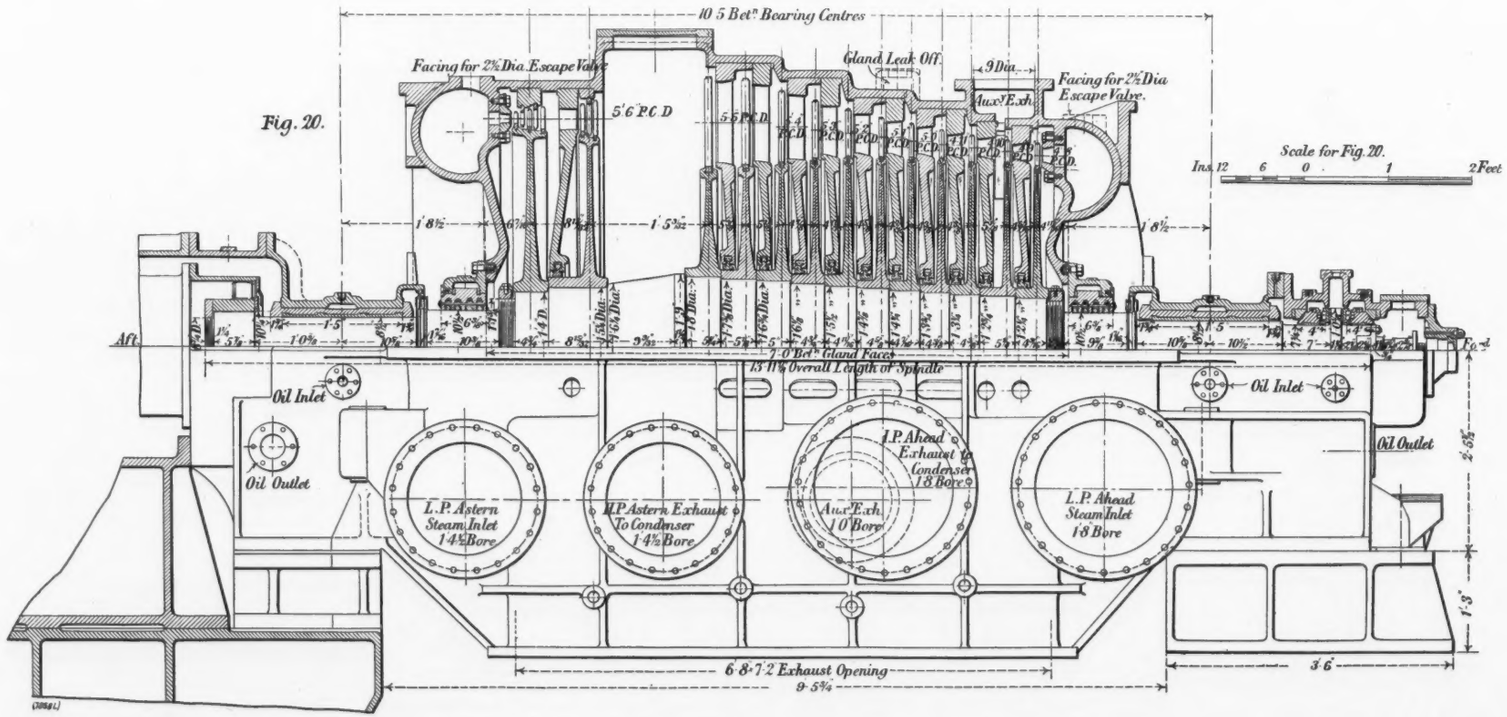


FIG. 20. LOW-PRESSURE AHEAD AND ASTERN TURBINES.

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

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Two-Page Plate.—TURBINES OF THE CUNARD TWIN-SCREW STEAMER "FRANCONIA."

ENGINEERING.

FRIDAY, JUNE 1, 1923.

THE GOVERNMENT'S NEW WORKMEN'S COMPENSATION BILL.

THE House of Commons on Wednesday of this week gave a second reading to the Government's new Bill to provide for compensation to workmen for accidents, and as the Bill makes very important changes, not only in the amount of the payments to be made by way of compensation, but also in fundamental principles, careful attention ought to be devoted to it by all interested in industry. A Bill became necessary in order to modify the increases made in the amounts payable because of the higher cost of living due to the war. Proposals are now introduced which considerably extend the scope of accident compensation. It will be remembered that no phrase in the original Act gave rise to greater difficulty in the courts than that which defined an accident for which compensation was to be paid as "arising out of or in the course of employment." In the new Bill there is a clause which provides that the employer cannot plead that the accident was caused by the man acting in contravention to statutory or other regulations, or of specific orders given to him by or on behalf of his employer, or that he took upon himself to do something that he had no business to do, provided it was "for the purpose of or in connection with his employer's trade or business." The words quoted are very extensive, and would practically embrace every accident, whether or not it arose "out of or in the course of employment," according to the wording of the original Act.

The prevention of accidents has very properly given rise to the enforcement of many statutory regulations, and this new proposal of the Government seems almost to nullify such statutory regulations for the prevention of accidents, because by neglecting them any worker may be involved in an accident and the employer be compelled to pay compensation for such neglect. At present the penalty for disobedience of such regulations may be accident without compensation, but if this is altered there will, undoubtedly, be greater carelessness, and consequently more numerous accidents. For instance, it is provided by statutory regulation that in a coal mine "if a shot misses fire the person firing the shot shall not approach or allow anyone to approach the shot hole until an interval has elapsed of not less than 10 minutes in the case of shots fired by electricity or by a squib, and not less than an hour in the case of shots fired by other means." Under the original Workmen's Compensation Act an accident due to the breaking of this rule does not involve compensation for the accident; but under the new proposals any accident which may result owing to the same cause would not free the employer from the obligation to pay compensation. Obviously some amendment is necessary to such proposals.

Another important departure has reference to the method of terminating weekly payments. The Bill requires that an employer must supply a workman with a copy of a certificate certifying him fit for work and notifying him of the termination of the weekly payments at the expiration of seven days. In the interval the workman may get a certificate from his doctor—probably a panel doctor—disagreeing with his employer's medical advice, and a dispute may develop involving reference to a medical referee. It is not difficult to conceive of a large number of such cases of divergence of opinion, and, apart altogether from the delays, there is the serious provision that the employer must continue the weekly payments until the decision of the referee has been given. Even if the employer offers the workman suitable light work, or his old job, the payments cannot be discontinued.

As regards the rates of compensation, very material additions have been made to those appertaining to the pre-war period. It will be remembered that under new Acts during the war considerable additions were made to the rates payable under the original Act of 1906. The War Addition Acts, increasing the rates of compensation, are to be repealed as at December 31, 1923, but the rate of payment in force at that date is to continue during total incapacity. Thus a maximum rate of 35*s.* is payable to a man who was totally incapacitated on December 31, 1923, although anyone injured on the following day (January 1, 1924) will only get 30*s.*—the new maximum rate. It will be at once recognised that this would be made the subject of a grievance on the part of the recipient of the latter sum. There is this further difficulty. A man at December 31, 1923, may have recovered sufficiently to resume work, but may later on have a relapse. Then he would become entitled to the resumption of compensation. Is the rate to be determined according to the date of the accident or the date when he had the relapse? The war additions involved an increase of 15*s.* per week, bringing the original rate of compensation of 20*s.* up to 35*s.* per week. The new Bill fixes the rate at 30*s.*, but, as already stated, those who are receiving relief prior to the end of 1923 continue at 35*s.* The increase was given because of the higher cost of living, and this cost has now considerably decreased. Why, therefore, continue the higher rate for anyone? If 30*s.* is adequate for one injured later than December 31, 1923, surely it is adequate for one injured prior to that date. If not, there is room for complaint by those who are injured at the later date.

The payment to widows and orphans of men who have been killed by accident is considerably increased. Where there are children under the age of 15 the maximum is increased from 300*l.* to 500*l.* The present maximum of 300*l.* remains unaltered if there are no children, but for each child the maximum to be paid is to equal 4*s.* per week until the child attains the age of 15 years. Consequently, if there is one orphan of 8 years of age left the total payment will be 372*l.* 16*s.*; if there were three orphans, aged 3, 5 and 7 years, the total payment would sum up to 612*l.*, but only a maximum of 500*l.* would be paid. We have founded these figures on the assumption that the average earnings of the workmen is 2*l.* per week; when a less sum is earned, the amount payable per child, per week, is to be 10 per cent. of the average earnings, up to the limit of 2*l.* per week. Thus in the case of a man getting

30*s.* per week the child would get 3*s.*, and where the child was 8 years of age when the accident happened to the father, the payment would be 288*l.* 12*s.*, instead of 372*l.* 16*s.*

An entirely new method of arriving at the compensation payable in the case of partial disablement is being introduced. The new maximum of 30*s.* per week applies to total and partial incapacity, and therefore involves a very much increased charge on the employer, because under the existing law the payment for partial incapacity is 20*s.* This 20*s.* was arrived at, under the original Act of 1906, by determining that 50 per cent. of the worker's earnings was to be the maximum. The 50 per cent. remains, with the addition that if compensation, calculated at 50 per cent. of the earnings is less than 25*s.* per week, the worker is to be entitled to half the difference between this figure of 50 per cent. and the 25*s.* or his average earnings, whichever may be the lower. In the case of workmen earning over 60*s.*, the maximum rate of compensation payable would be 30*s.*; in the case of workmen earning 50*s.* to 60*s.*, they would get 50 per cent. of their earnings. A workman earning 49*s.* would get 50·5 per cent. of his wages; one earning 26*s.* per week would get 73 per cent.; and a workman earning 25*s.* would get 75 per cent. Under the present law the amount was determined by the courts beyond the maximum of 20*s.*, and the decisions of the judges varied from 50 per cent. to 100 per cent. But it will be seen that under the new scheme the lower-paid workmen get a higher rate of compensation. It is a question whether this is fair, but apart altogether from that the scheme is undoubtedly very complicated.

There is, too, a difficulty as to the period to be taken to determine the average wage of the workman before the accident. A difficulty may arise also as to whether, in the event of a long period of incapacity there is to be taken into consideration any reduction in wages in the trade in which the workman was engaged when injured. We may assume, for instance, that the average wage of the workman before the accident was 4*l.* per week, and that he was incapacitated for two or three years. In the interval the wages of his co-workers may have been decreased to 3*l.* or even 2*l.* 10*s.*, and consequently the injured man might be in a better position than those of his co-workers who had not had the "misfortune" to be injured. In other words, the new Bill fixes definitely that the basis of payment for partial incapacity is to be the difference between what the man is earning or is able to earn and what were his average weekly earnings before the accident. Under the original Act it has been upheld by the courts that the workman is paid compensation for incapacity to earn, owing to injury. Although the workman's average earnings before the accident might have been 4*l.* per week, the employer was not liable to pay compensation to make the total up to 4*l.* per week where the worker was able to do light work if the wage had been reduced to such an extent as to bring the earnings of an uninjured man at his trade down to 3*l.* per week. The employer was only called upon to make up the difference in the case of the partly disabled man between 2*l.* and 3*l.* namely, 1*l.*, and not the difference between 2*l.* and 4*l.* This seemed a reasonable proposition, and it is to be hoped that some consideration will be given to this question in determining the rate for partial disablement.

BRITISH INDUSTRY AND THE RUHR.

THOSE who still cherish the delusion that the French occupation of the Ruhr will prove a stimulus to British industry have, unhappily, received yet another proof of their error. Mr. Douglas Vickers, in his review of the past trading year of Vickers, Limited, alludes to the effect of the international situation on British engineering in the following terms: "Coal and coke companies and makers of raw steel of ordinary qualities have gained a passing advantage, but on the whole the French occupation of the Ruhr is causing a considerable loss to the engineering trades of this country. Under the circumstances it is not easy to forecast the results of the year 1923. I can only say that, unless there is a definite change, this year is not likely to be different from 1922." Mr. Vickers was the more reluctant to accept this conclusion because signs of improvement at the end of last year had been unmistakable. Last July he had been able confidently to predict a break in the clouds. Only a few months ago he would have said that his hopes were on the point of being fulfilled. In December there was "a distinct revival in the steel trade, more inquiries for shipbuilding and engineering material, and a general feeling of greater confidence which we all thought the beginning of better times." Upon this as yet frail and delicate shoot the French Ruhr occupation fell like a blight. "The production of coal and steel in that district was reduced and diverted from its natural course, with the result that the prices of coal and coke rose here and that of steel followed." The natural result was "the rise in the cost of ships and engineering products to a price which holds off the few buyers who have not already been frightened away by the uncertainty of the political situation." This statement—coming as it does from the chairman of one of our greatest engineering firms, who knows the steel trade and who, having received part of his training in Germany, is well acquainted with German conditions—is unequivocal with regard to British engineering. Indeed, to those not blinded by political or national prejudice, such consequences have appeared inevitable from the first.

Unfortunately the malign influences of the Ruhr are not confined only to engineering. Mr. Vickers has touched the heart of the question when he refers "to the general feeling of greater confidence which has now been dispelled by the uncertainty of the political situation." It is precisely that general confidence which would, if restored, bring back our foreign markets for every manner of commodity and revive British industry and commerce. It is simply the "political uncertainty" which is responsible for our domestic problems, unemployment, stagnation, bankruptcy and all the distress that they imply. Noteworthy amongst the efforts to compel recognition of this truth has been the campaign conducted recently by the Industrial Group of the House of Commons. That body, under the presidency of Sir Allan Smith, chairman of the Engineering and National Employers' Federations, has continuously urged upon the Government the paramount importance of a general European settlement to the reduction of unemployment in this country and the revival of British industry and commerce. The group has striven to show that the restoration of international confidence should overrule in importance most practical and all sentimental considerations.

We have now gone as far as we can at putting our own house in order without reference to the external situation. The preponderating factor in our industrial life is our dealings with foreign markets. Those markets are closed to us partly from the material dislocation of currencies and exchanges and partly from the psychological atmosphere of instability arising from fear of political and military adventures such as the Ruhr. That atmosphere, added to normal business risks, makes commercial and industrial transactions impossible. It is clear, therefore, that foreign problems have got to be tackled for our own sakes. We may wish to be benevolent neutrals. We may prefer to sympathise with out late ally and desire to leave Germany to a well-merited punishment. The hard fact is that we cannot afford to. It is not a question of pro-German or anti-French propensities, but solely of pro-British necessity. The belief that "the destruction of our most formidable trade rival" will redound to our advantage must be abandoned in face of the teaching of economic laws. If we are not to lose the fruits of the efforts and sacrifice of post-war years we must now make a definite move for a European settlement. Nor can it be a mere suggestion. We must be prepared to support the proposal with all the influence of the Empire and all that we can command outside it. With this in view the Industrial Group has urged a World Economic Conference summoned by Great Britain and the United States of America, to consider a settlement of international indebtedness (including German reparations), the economic reconstruction of Europe and problems of security. It has also made a thorough preliminary investigation of these problems with the object of presenting a concrete plan of action to the Government.

The conclusions drawn from this investigation are that the political motive in international relations must be superseded by a commercial motive. The nations can and must be "commercialised out of the spirit of aggression" by giving them a greater stake in maintaining peace than in promoting war. England, the United States, Russia and Germany, if not also France, should form a great economic *entente*. If these nations set their faces against war it could not be. Once they could be brought together in council the probability of future Ruhr incidents would be reduced to nothing. Security should be guaranteed internationally; international indebtedness should be cancelled as far as possible and fixed at reasonable and definite amounts where war obligations are outstanding. Moreover, action to promote these ends is of the utmost urgency and should be undertaken at once. Mr. Vickers, who was able to speak hopefully last July, was clearly not a pessimist. He tells us that we may expect 1923 to be a repetition of 1922. Are we to allow this? Can we support another slump year and another winter of unemployment? Industry and commerce nowadays are international. It is precisely for that reason that the Ruhr problem affects every individual in this country. Government, employer and workman alike must combine to force matters into a better channel if Mr. Baldwin's Administration is destined to lift us from the slough of post-war depression.

THE STATUS OF THE TECHNICAL MAN.

IN ordinary business life the reins of control are usually held by the men who provide the funds by which business is carried on. This is reasonable, and even inevitable, but it may be doubted if it always tends to the greatest efficiency or success. Financial ways and means are for the most part controlled by business men who are not technicians, and too rigid a control by such men is likely to lead to a level of success somewhat below the best possible. We naturally look at this matter from an engineering point of view, and it is in activities of the highly technical kind which engineering manufacture represents that this effect is likely to be most marked. Technical matters can only be properly understood by technical people, and an inappreciation of the importance of a technical change in method, for instance, may well have serious effect on the fortunes of an engineering firm. The most striking financial successes in engineering manufacture will usually be found to be associated with control by engineers, and it is difficult to imagine for instance that any ordinary commercial board of directors could have carried through, or would have permitted, the technical proceedings on the result of which the success of the Ford motor business has been built up.

This ultimate control of technical activities by non-technical minds may be defended in ordinary business life since the funds are usually provided by the owners of the non-technical minds. In public affairs, however, matters are different. The funds in that case are provided by the taxpayer, and although there are more non-technical taxpayers than technical ones, the public interest is that the funds should be administered as efficiently as possible, not that they should be administered by men of the same technical ability as those who find them. The measure of freedom which leads to the great successes of commerce is not possible in public affairs, but within the rigidity of control which is one of its necessary features, it would appear possible to take fuller advantage of technical possibilities than is common in perhaps the majority of commercial transactions. Instead of this being done, however, it is usual to adopt one of the weaknesses and incidental features of commerce, as if it were either a virtue or a necessity, and to place final responsibility for technical matters in non-technical hands.

The idea that ultimate control in a public department, no matter what the nature of its duties, should be in purely administrative or clerical hands

is presumably copied from the basic idea on which the Government of this country is conducted. The idea of Parliament as the supreme arbiter and local councils as mediate arbiter in local affairs introduces the basic notion of non-expert control, since although the electors might theoretically return a Parliament, or local council, composed entirely of technical men, there is no presumption that they should do so. The extension of this idea of non-technical control to public departments is, however, not logical, since the cases are not parallel. Quite apart from the fact that the individual member of Parliament is returned by the electors who have the theoretical right to choose whom they like, the functions of Parliament and those of a public department are not similar. Parliament has to deal with any question which may arise and if a medical man is returned as a member, although his opinion may be of particular value in some question concerning the Factory Acts, there is no presumption that his judgment on a question of national defence will be of any more value than that of the least technical member. The staff of a public department, however, has in a general way to deal with one class of matter only, and it would seem that the administration of the department might well be in the hands of an expert in the matter concerned.

The idea that technical questions are best dealt with by a man who knows something about them has gained some ground of late years, and one has seen several engineers appointed general managers of great English railways, while the creation of the Electricity Commission is evidence of some appreciation of the same idea in Governmental circles. We have still a long way to go, however, before it shall be taken as a matter of course that a technical man of suitable attainments shall be the best paid servant in all public departments dealing with technical affairs. In general it is still assumed that heads of departments in the civil service should be men of the purely administrative or clerking type, and technical civil servants are still subjected to non-technical control. A growing realisation of the fact that most of the real work of the world is being done by men of the doctor and engineer type is, however, leading to a somewhat improved status for technical men generally, and the situation is being helped by a growing realisation of their obvious rights among technical men themselves.

An attempt is being made to introduce a fairer and a sounder practice in the Civil Service by the Institution of Professional Civil Servants which was founded at the beginning of 1919. The purpose of this Institution is "the improvement and maintenance of the position and status of civil servants of the Crown (established or unestablished) of the directing, administrative or higher grades and engaged in professional, technical or scientific work." The body is in no sense a Trade Union and by its Memorandum of Association may not support by its funds or endeavour to impose on its members any regulations, restriction or condition of a Trade Union nature. The Civil Service deals with a great variety of technical matters, but each type of worker is ensured that his particular interests shall have proper representation owing to the affiliated Associations in conjunction with which the Institution works. There are 41 of these affiliated Associations, each nominating representatives to the Institution Council. Each represents a special activity, and the nature of the associations will be best understood by quoting the names of a few of them. In the Admiralty there is for instance, the Association of Cartographers, the Royal Corps of Naval Constructors' Association, &c.; in the Board of Trade, the Patent Office Examining Staff Association, the Association of Board of Trade Surveyors, &c. In the same way each Civil Service Department is represented by one or more Association standing for the interests of a particular type of worker.

It is possible that the most valuable work which the Institution of Professional Civil Servants can do is of an indefinite nature in giving the workers it represents a corporate voice and enabling them to speak as one body on matters affecting their interests. The mere existence of the Institution gives an added status to the scientific and professional men which it represents, and if it is wisely conducted, as we have no doubt it will be, it should help towards the time when the technical workers will be realised to be the most important units of the whole service. It is clear that questions affecting salaries may fall to be dealt with by the Institution, and while we particularly desire not to give the idea that the main object of the body is to get more money for its members, there is a question under this head which should be mentioned. It was referred to by the President, Sir Richard Redmayne, at the annual dinner, which was held on the 25th ult. We can best explain this matter by quoting his words. Sir Richard said "professional civil servants suffered under the economy campaign without having benefitted by the previous more generous mood of the Government. Thus, last year, it was decided that in addition to the reductions in Civil Service bonus which should take place as the cost of living figures fell, there should be an additional reduction in the bonus of all basic salaries of over 500*l.* a year. In all cases except those of professional Civil Servants these salaries had received substantial increases in previous years, and the cut was to some extent merely a taking back of part of what had been added. In the case of professional men, however, the basic salaries had not been increased, consequently the cut was an actual reduction to a level below that of the pre-war period."

It is evident that in this case the Institution is making no complaint about any general attempts at economy in Government Departments, but is naturally complaining that the class of servant which it represents should be singled out for specially harsh treatment. The value of their work and the special knowledge they bring to Government service, should entitle professional Civil Servants to a higher rate of remuneration than purely clerical members and, although recognition of this fact may hardly be expected just yet, common justice dictates that the two classes should at least be treated on a level. This example, which Sir Richard quoted, is ample justification in itself for the existence of the Institution of Professional Civil Servants, and one trusts that its representations and the growing authority with which it will speak will serve to rectify such injustices and to bring about a state of affairs in which they will not be able to rise.

ECONOMIC CONDITIONS IN FRANCE.

THE rapidity with which France recovered from the war of 1870, her payment in less than the stipulated time of the war indemnity imposed upon her by an implacable victor, the fact that she was able to organise and to hold an international exhibition in 1878, so early after the disasters she suffered at that time, have always excited the admiration of the world. The late war has been far more disastrous than the one of 1870, and the injuries it has caused in every sphere will take long to make good again, particularly in our own country where industry and commerce predominate so extensively over agriculture. Immediately the war ceased in November, 1918, France commenced heroically to repair the dilapidation created in her northern territory, and she is still continuing operations with her own resources. Whilst our own sufferings in this most unjust war and the work which we ourselves are carrying out in order to make good our own losses cannot be lost sight of, we are afraid that the French situation is not considered from the right standpoint and with suitable means of observation. The attitude taken up by many outside beholders may, in fact, be likened to the examination of a masterpiece in architecture through a magnifying glass or a microscope, and these media are not those to use in the particular instance. The situation has to be considered as a whole, distances come into play, and we feel certain that in twenty years time the efforts now being made by our French friends will be much more highly appreciated than they are now. While we are dealing with this aspect of the case, we should like to add a word of testimony to the engineers in the liberated regions who are making good their country's losses; they are doing so most unassumingly, and from day to day they are proceeding with their work with every possible energy. Their constancy has all our admiration.

In a series of three articles in former issues (see ENGINEERING, vol. cxi, pages 604, 670, and 782), we gave an outline of the war damage, wanton damage mostly, done by the enemy to the mines, iron and steel works, railways and canals in the northern districts of France. Similar articles might have been written covering the textile and other industries of the same localities. The work of reconstruction in the liberated regions is not yet complete, but it is very satisfactory—so far as it goes—to note from a Report on Economic Conditions in France, by Mr. J. R. Cahill, Commercial Counsellor, British Embassy, Paris, recently issued by the Department of Overseas Trade, that this work has made great progress, despite difficulties mostly of a financial nature. It is the French State which has had to bear the burden of financing the reconstruction work hitherto. A statement made in the French Parliament last November was to the effect that the French expenditure on the devastated areas had reached 45,000,000,000 francs at the end of June, 1922, and that the operations still to be carried out would require about 55,000,000,000 francs. The report takes the case of the Department of the Nord as an illustration, and states that the position in that Department on June 30 last was such that out of a bill for reconstruction purposes of approximately 32,000,000,000 francs, the State had discharged 15,200,000,000 francs, both for industrial and non-industrial reconstruction. Practically all this money, the report adds, has been met by loans, which it was hoped to repay out of the German indemnity. This indemnity is not yet forthcoming. In these circumstances the economic position of France need be strong, and we are glad to find, according to the opening statement of the report, that it is.

The industrial population of the country is stated to be fully employed, and the output in most fields of production to be limited only by the dearth of man-power. In many industries, we may add, France is well to the front; many of her discoveries, in metallurgy, for example, have been epoch-making. Her main resources, however, may be said to have lain, hitherto, in agriculture and in industrial products directly derived therefrom; she has lost much by the withdrawal of a large proportion of her agricultural population to meet the war needs. Matters in this respect, it is satisfactory to find, are improving greatly, the scarcity of home labour in agricultural pursuits having been partially met by the introduction of a considerable number of foreign workers and by the more extensive application of machinery. A significant statement in the matter of agriculture is to the effect that the prohibition of the export of rye flour has been reimposed by a recent decree, the measure with regard to rye being to conserve stocks in the country, since rye, with rice flour, is to be used until the next harvest to eke out wheat—to a maximum limit of 10 per cent.—in the making of bread, in view of the deficiency of the French harvest of 1922. This, as may well be expected, has an important bearing upon the cost of living in the country, under which heading it is remarked that the general tendency of wholesale prices in France has been distinctly upward since February, 1922. In that month the official index figures for the wholesale prices of 45 commodities was 354, the prices of 1901–1910 being taken as a base at 100. It had increased to 407 last November. The figure averaged 399 for the year 1921. The figure for food products last November was 384. Wages, on the other hand, have evinced in general very little tendency towards diminution since the beginning of 1922, and at the present time they appear to attain levels which are, generally speaking, from three to four times higher than those prevalent in the same occupations before the war. Up to 1919 the customary hours of labour in industrial establishments were 59 or 60 per week. Under the law of April 23, 1919, the principle of the eight-hour day was introduced, but provisions were included admitting of exceptions being granted by the State. At the present time the 48-hour week is the accepted and legal standard throughout the industries of the country.

France suffers considerably, as we do, from the housing difficulty, but in her case the matter has been complicated to a most painful extent by the destruction in the devastated areas of nearly

300,000 dwellings and the more or less serious damage inflicted on half a million more. Other circumstances have also intervened, and rents have been considerably increased. New tenants pay rents at least double those of 1914, and also upkeep and other extra charges formerly included in the rent or borne by the landlord. The French dwellings are generally a flat or part of a flat, in both cases limited as to size and conveniences, and located on any storey of a large building, which renders a comparison with the prevailing conditions in England almost impossible. Taken as a whole, however, the housing problem in France is far more serious than it is here, in every one of its aspects.

The report further points out the various measures to which France has had to resort with a view to meeting emergencies in every field of activity, notably measures of a financial nature in which we need not enter in this brief review. Not only is she making good practically unaided the ravages of war, but her ports, waterways, railways, roads have been and are being further improved; her water-power is being systematically turned to account and new and modern factories for the principal branches of industry have sprung up. In the metallurgical and engineering industries, particular notice is called to the activities displayed by the Schneider concern, the Forges et Aciéries de la Marine et d'Homécourt (St. Chamond) Company, and others.

The impression gathered from reading Mr. Cahill's remarks is one of admiration for the indomitable energy displayed by our French friends in meeting all their post-war problems, problems which, it should never be forgotten, are none of their seeking. We hope the task with which they are confronted will soon be overcome and that an era of great prosperity for them will follow. They amply deserve it.

NOTES.

The Industrial Applications of Interrupted Light.

The fact that the retina of the eye, or, at any rate, the mind of an observer retains the impression of sight for a tenth of a second or so after the stimulus has ceased is well known, and forms the basis of the illusion of motion given by the kinematograph. If the series of pictures follow one another quickly enough, the eye fails to realise that they have been interrupted and conveys to the brain the impression of continuous vision. It is therefore evident that if pictures were taken of a reciprocating or revolving object, and if they were so timed that every picture coincided with the return of the object to the same position, the effect would be to represent the moving object as stationary in the particular phase of its motion depicted. It is also clear that the same effect may be produced if the moving object is illuminated by a succession of properly timed flashes of light, and some practical applications of this principle were demonstrated by Dr. J. F. Crowley in an interesting lecture before the Illuminating Engineering Society, entitled "The Use of Synchronously—intermittent Light in Industry," on May 24. Intermittent illumination was provided by the flashing of a neon lamp, which could be lit and extinguished much more suddenly than any other type of lamp. The flashes were caused by a mechanical make-and-break apparatus driven by the machine under observation, so that the necessary exactness of timing could be obtained. By mounting a Drysdale stroboscopic disc on the end of the shaft of an electric motor, and observing it by the neon light, the exact moment when certain speeds were obtained could be noted by the stationary appearance of one or other of the polygonal figures on the face of the disc. Thus accurate curves of acceleration or slowing down could be obtained. Another application of the principle was the Elverson oscilloscope, which was fully described in ENGINEERING of December 8, 1922. Viewed by the neon lamp, the mechanism of a sewing machine working at full speed appeared stationary, and a number stamped on a lever vibrating many hundred times a minute could be read without difficulty. By altering the timing of the flashes the machine could be made to appear moving slowly forwards or backwards as desired, and any phase of the motion could be examined. By the use of similar means it was possible to inspect any rapidly-moving elements of a machine, such as the travellers of a ring spinning frame, or the tappets of a motor car engine.

The Hadfield New Rolling Mill Plant.

Messrs. Hadfields, Limited, have recently put down at their East Hecla Works, Tinsley, Sheffield, a new rolling mill plant, consisting of a 28-in. heavy mill and two bar mills of 11 in. and 14 in. respectively. The larger mill was started running by H.R.H. the Prince of Wales in the course of a visit which he paid to Sheffield last Tuesday. This mill is to be used for rolling down ingots into billets and also for the rolling of "Era" manganese steel rails. The cogging and finishing rolls are 28 in. in diameter, the former being 7 ft. in length and the latter 6 ft. 6 in. The total weight of the mill complete is about 1,600 tons, including the electrical equipment which weighs approximately 400 tons. The main rolls were made of special quality forged carbon steel in Messrs. Hadfields' own works. The hydraulic shears are of the up-cutting type complete with hydraulic intensifier, arranged for a maximum power of 1,000 tons and capable of shearing "Era" manganese steel blooms, when hot, up to 10 in. square. The hot saw is driven by a 75 h.p. motor and is of the horizontal sliding type having a blade 60 in. diameter. The mill motor has an R.M.S. rating of 3,200 h.p. and a maximum rating of 11,600 h.p. It is capable of exerting a constant torque of 125 tons-ft. from standstill to 60 r.p.m. in either direction, and gives a constant horse-power of 3,200 between the speeds of 60 r.p.m. and 120 r.p.m. The overload capacity corresponds to a torque of 453 tons-ft. between standstill and 60 r.p.m. and 11,600 h.p. between the speeds of 60 r.p.m. and 120 r.p.m. The cast steel flywheel, made by Messrs. Hadfields, is of the built-up type, 11½ ft. in diameter and weighing 30 tons. The flywheel set consists of a 1,800 h.p., three-phase motor, with two dynamos of 6,000 h.p. on the same shaft, there being farther along the shaft a 30-ton flywheel; the set is interposed between the power lines of the Sheffield Corporation and the main mill motor, in order to supply the large machinery demand for power. The main mill motor is capable of being reversed from full speed in one direction to full speed in the other direction in 3 seconds or 4 seconds. The rolling mill plant as a whole covers an area of about 4 acres, of which the rolling mill shop proper occupies close upon 2 acres. This shop is one of several which Messrs. Hadfields put down during the war for the manufacture of large calibre high explosive shells; they have modified it for its new purpose. It is served by 20-ton and 35-ton electric overhead travelling cranes; open-hearth steel ingots are conveyed hot to the rolling-mill building and two reversing, regenerative, continuous, gas-fired furnaces have been installed for dealing with special alloy steel ingots which have to be heated gradually from a cold to a rolling temperature. A large soaking pit capable of containing 24 ingots has also been provided. Five gas producers, each capable of dealing with 10 cwt. of coal per hour, supply the necessary gas for the furnaces and soaking pit. This new rolling mill, together with the two smaller ones, also electrically driven, forms a most interesting addition to Messrs. Hadfields' works.

Industrial Physical Research in America.

Sir J. J. Thomson devoted the short presidential address, which he gave to the Institute of Physics at the annual meeting, held in the rooms of the Royal Society last Wednesday, to the position of industrial research in America, which he had recently visited. The scientific movement over there, which would convert any sceptic, was quite modern and had not been started without opposition. Its pioneers had had to fight shareholders and co-directors, and pointed questions had been asked when the first accounts had been discussed. At present all the business men whom he had met had assured him that the research department was one of the most profitable, and even if expenses went up by leaps and bounds, that department would be the last to be reduced. The scale of operations in some of these research departments was enormous. The Western Electric Company had an immense building for research and development in New York, and spent a million pounds on it annually. Much of the work he had watched there could only be described as purely scientific; *e.g.*, the inquiries into the effect on the intelligibility of speech of cutting out certain frequencies—which did not impair audibility—and into the scattering of cathode rays by monovalent and divalent elements. The discovery of an alloy of extraordinary magnetic permeability, the direct soldering without cement of copper to glass, and the 50-kw. thermionic valves which promised to give us Transatlantic telephony within a year, were other matters. In the laboratories of the General Electric Company, which probably cost more than 200,000*l.* annually, more research and less development work was done. These institutes were attached to single firms; the advantage was that results were their own and had not to be shared with other firms or associations; co-operation between the highly-capitalised American firms was more difficult than over here. The universities of the United States could likewise command very ample funds; he had taken part in the opening of the new chemical laboratories at Yale, built at an enormous expenditure. Perhaps too big, Sir Joseph thought; gradual development had its advantages. In considering the means at the disposal of these institutes one had to consider that little deference was paid to mere money in America. Wealth could buy neither honours, nor social distinction; much was therefore done for the public benefit, and that was a great asset of America. In another respect, as regards secondary and university education, England had the advantage. The tone in the great American research laboratories was excellent; but it was difficult to find competent men. Few of the students came to college with an appreciable knowledge of mathematics or of difficult subjects generally; the secondary education was too much adapted to the average demands, and at college no distinction was made between honours men and ordinary students. To do that, in science, would be considered "undemocratic," though highly-specialised athletic courses were not undemocratic. Sir Joseph expressed the hope that England would maintain the present high standard of her secondary and university education. Sir Charles A. Parsons, we should add, succeeds him as president of the Institute of Physics.

The Physical Chemistry of the Photographic Process.

The general discussion of the "Physical Chemistry of the Photographic Process," which the Faraday Society held on May 28, 3 p.m. to 10 p.m., was originally planned for 1914 and, so far as finality of any theories comes into question, might have been postponed another decade. That remark does not mean that no progress has been made of late, nor that such progress was not brought before the meeting. On the contrary; the activity in photographic research has been intense, and the 28 papers discussed well characterised the recent work. The papers were contributed by Professor Wilder Bancroft, of Cornell University, Professors R. Luther and E. Goldberg, of Dresden, J. Erréra, of Brussels, and M. Clerc, of Paris—all of whom were present—by Messrs. E. P. Sheppard, F. P. Whightman, W. Bullock and others of the Eastman-Kodak Research Staff, Rochester, New York; by Mr. Olaf Bloch, of the Ilford Research Laboratory; by Drs. T. Slater-Price, E. C. Toy and W. C. Clark, of the British Photographic Research Association; by Mr. T. Thorne-Baker, of the Imperial Company's Research Laboratories; by Dr. Lüppo-Cramer, of Schweinfurt, Professor Christian Winther, of Copenhagen, and others. But it did not require the paper by Dr. J. Plotnikov, of Agram, on "Future Problems in Photography" to emphasise how much remains to be done. Professor Bancroft, who introduced the discussion by a paper on the "Theory of Photography," gave an outline of the theory of development, considering that the question of the latent image was well cleared up—which was by no means conceded by other speakers—and that the theory of emulsion was still very much in the

air—which the discussion certainly confirmed. Both Professor Bancroft and Dr. Slater-Price regretted that plate manufacturers withheld information so that scientists did not know what plates they were really experimenting with. Mr. Storr, of the Ilford Company, admitted that information was withheld; he doubted, however, whether that information would be of much scientific importance. But it is not yet understood to what the sensitiveness of the emulsion is really due, nor why most developers give negatives while others, under similar time conditions, at once give positives, and such questions can only be decided by the fullest knowledge of the mode of preparation of the emulsion. In spite of the very large number of papers there was very little overlapping, and the tone of the discussion was highly technical throughout. We may notice one novelty, the Grey Wedge Sensitometer of Dr. Goldberg, who demonstrated the simple method of making his improved wedges. He fills the wedge-shaped space between two glass plates, 2 mm. apart at the wide end, with a coloured solution of gelatine; the wedges of all colours dry within a few minutes; for work in the ultra-violet he makes use of the developed grains of silver. Exposing such wedges, simple or crossed, together with the ordinary plate, and combining them with chequered scale-plates, Dr. Goldberg studies the light distributions over images, and he easily obtains sensitometer curves, with the aid of a simple instrument. By the further use of three little brass discs, placed between the photographic plate to be measured and a glass plate, he also determines whether there is halation or fog. We may also mention that according to Messrs. Lumière and Seyewetz, of Paris, the reddish tone of some silver prints is due to a double sulphide of silver and gold.

LITERATURE.

Gliding and Soaring Flight: A Survey of Man's Endeavour to fly by natural methods. By I. BERNARD WEISS. With a preface by C. G. GREY and an appendix by W. H. SAYERS. London: Sampson, Low, Marston and Co. [Price, 5s. net.]

IT is difficult and invidious to attempt to appraise the merits of the contributions made to the development of aircraft in its various forms. The advocates of experiment and of theory stand in opposed camps, each claiming that their contribution has led to the achievement of practical aviation. That each has assisted in discovering the principles underlying the science and in accumulating the data of aeromechanics may be admitted without injustice to either. At the present moment, however, owing to successful experiments in gliding with unengined machines, both in this country and on the Continent, there seems to be a tendency to give undue prominence to the efforts of pure experiment, and to belittle the exertions of those who have struggled strenuously to achieve practical results, and have made rapid locomotion by aircraft both possible and certain.

The contributors to this volume and especially the writer of the preface, Mr. Grey, look to the knowledge acquired by experiments in gliding as supplying the best, if not the sole, means of perfecting aeroplane construction. The influence of the war in stimulating the science of aviation, and in confining investigation to a particular direction, he regards as unfortunate and retrograde. "As a matter of fact," he writes, "the war has seriously hindered aeronautical progress, and there are many who look to gliding as the best way towards making up for the progress lost during the war." We cannot regard this statement as justified. It is urged that what the war has produced has been, by the prodigal use of money, the construction of very bad aeroplanes and very bad engines, with which have been accomplished some feats that look like very good performances, "whereas if we had only had the old pre-war materials, we might have achieved a much higher degree of efficiency in our dealings with the air itself." To return to the method of gliding as a means of locomotion or transport, after what has been achieved by engine-driven aeroplanes, seems equivalent to abandoning the use of steamers and replacing them by sailing ships. Rapidity of action, certainty of direction, and the maintenance of punctuality, have been secured, and these advantages are not to be despised because they have been secured by what the author calls "sheer brute force." Possibly there may be a wasteful expenditure of force, but the world's work goes forward in a way that would be impossible with less powerful and less manageable craft. The Germans, being restricted in the use of aeroplanes by treaty obligations, are commended for returning to the elemental stage and renewing experiments with gliders without engines, and Mr. Grey confidently predicts that this rational step will meet with its due reward, by conferring increased efficiency, stability, and control on aeroplane construction, that in its turn will ensure cheapness and safety in flying. We cannot share this optimism. Just as a sailing ship can do nothing that a steamer cannot do, so it is difficult to see that an unengined aeroplane will find itself in a more favourable position than one fully equipped with improved engines.

Perhaps the time is not yet come when it is possible to write the history of aerial navigation, to see clearly the steps that have been epoch-making and to do justice to the adventurous spirits, who, too often, have given their lives in hazardous attempts to acquire control over the shifting movements of the atmosphere. From time to time, early craftsmen have won reputations and public acknowledgment by their unshaken courage and contempt of danger, but unguided by science have made little true progress, while others gifted with a keener appreciation of the principles of aerodynamics have advanced the science more noticeably without receiving their meed of recognition. Mr. Weiss endeavours to do justice to all, and especially to those who have laboured in face of ridicule and discouragement to point a way to the goal of success. The catalogue is a long one, and it is not easy to discriminate between the claims of many earnest workers, whose perseverence was greater than their science, and who added dexterity of manipulation to trained observation. The author might have given a more critical examination of the processes employed, thereby assisting our judgment to decide between the efforts of those who simply repeated with small alterations the schemes and mechanical appliances which earlier workers had tested, and those who made generic improvements that have proved their value.

We are disposed to give great credit to Sir George Cayley, who more than a century ago attempted flight or gliding without the guidance that a score of later enthusiasts supplied. Without having access to his original papers, we are prepared to accept the authors' conclusion "that he (Sir George) anticipated in almost every material particular, the aeroplane of a century later, . . . the serious nature of his work invested it with the scientific dignity which it had so long lacked, and which was so essential to secure its promotion as a branch of knowledge." In the next eighty years, it is difficult to see that any great advance was effected. The study of the flight of birds was much in vogue, but those who sought to find the solution of the problem in the behaviour of the condor or the albatross were following a false scent. The guiding and balancing power in a bird is a part of the machine, but in the case of mechanical flight or of gliding, the navigating and controlling power must be supplied by a man who is no part of the machine, but something external and carried by it. The bird presents in its muscular and nervous system a complete machine. To supply intelligent direction, the aerial conveyance must be completed by the addition of the pilot, and this addition introduces such complication that the bird hardly serves as an instructive subject for study in the matter of flight.

Lilienthal in Germany and Pilcher in England, both of whom gave their lives to benefit the cause they had at heart, are names that should long be held in honour, and the author describes their work and achievements ably and symphathetically. But their greatest service consisted in directing increased attention to the possibility of aerial locomotion, and in inspiring others to continue the investigation they themselves had so ardently pursued. Simultaneously in various centres, important, and in some respects, decisive advances were attained. Chanute insisted on the necessity of stability, the brothers Wright, inspired by Lilienthal's work, followed in his footsteps, and sought to sail through the air on fixed wings deriving the motive power from the wind itself. But another school was rapidly coming into prominence, led by S. P. Langley, to whose pioneering work the author hardly does justice. It may be claimed for him, that he toiled unremittingly to build up the basic science of mechanical flight, and that he applied his acquired knowledge to practical use by launching the first engine-furnished aeroplane, capable of prolonged free flight and possessing inherent stability. But by this step, Langley forfeits the author's good opinion, since he forsakes the original project of finding a solution to the problem of flight, as exhibited in the easy movements of a bird. The author belongs to the school whose aim is to utilise for the purposes of locomotion the power supplied by the air itself. Urged by this motive, a full account is given of the experiments of José Weiss and Igo Elrich, who believe in practising the methods of natural flight. We are glad to have this description, for these experimenters have accomplished much and by their example, more may be effected, though we fear that their exploits will not inspire the man in the street with "a confidence of safety born of a sense of knowledge of complete control of machine and element."

Das Moderne Siemens-Martinstahlwerk. By HUBERT HERMANNS. Halle a/S.; William Knapp.

THE technical production of steel can be considered broadly from three main points of view, each of which is complimentary to the other and all equally important. They can be perhaps referred to as: (1) the metallurgical (2) the engineering and (3) the economic. There have been numerous articles scattered through the periodicals of the world dealing with many aspects of all of them, and a few books which have collected the outstanding principles of the first and third, but there is an almost complete absence of any published works dealing with the second.

Why this should be so it is difficult to understand. The industry is one of the highest importance; it is carried out under very similar conditions in every country, and such local variations in method which occur are but very minor changes from the main principles. The book under notice is one which deals broadly with the whole subject, and it attacks it in a manner which is systematic and satisfactory.

It opens with a short history of the Siemens-Martin process in which the origin of the different methods of making steel in the Siemens furnace are succinctly stated. Although in this country the designation used for the open-hearth process is "Siemens," on the Continent it is always referred to as the "Martin" process, but there is no doubt that the modern method of making steel owes more to the genius of Siemens than to the brothers Martin in France. To begin with the furnace was wholly Siemens' invention, but the method employed by the Martins at Sireuil was to use the furnace to melt down a mixture of pig-iron and scrap in order to obtain the correct carbon content. Siemens, on the other hand, while recognising the advantage of utilising scrap relied also on the addition of ore to the furnace in order to oxidise the carbon out of the mixture, and he quite clearly foresaw that by the use of pig-iron and ore alone, low carbon steel of good quality could be manufactured. He was at once the pioneer and the far-seeing prophet of the most advanced modern practice.

How slow was the development at first can be judged by the table which the author gives showing that in 1897 there were only 16 furnaces over 20 tons capacity in Germany out of 192 in use; most of the furnaces being only 10 tons to 15 tons capacity.

The bare outlines of the metallurgical theory are given before starting the real subject-matter of the book, which is commenced by a short consideration of the lay-out of steel works from the point of view of the handling of the raw materials and of liquid pig-iron from the blast furnaces to the steel works, the handling of ingots, and the principles underlying the general arrangement of the railway lines between the different sections of the works. This last item is one where the free application of principles which are in themselves elementary is often restricted owing to pre-existing conditions on the site, but in many works in Britain even allowing for such

restriction the plan of the railways has been allowed to assume a strong resemblance to a nightmare owing to the neglect of even these very elementary principles, and inconvenient working and expensive haulage in consequence are making themselves heavily felt at such times as the present.

In each of these sections the facts are illustrated by reference to selected ground plans of existing works. Developing the subject further, the author begins the consideration of the lay-out of the different sections of the works to one another and the detailed examination of that portion of the work which each section has to perform. The yards for storing scrap, coal, refractories, moulds, &c., can all be arranged so that the handling and the discharge to the next stage of the materials required by the furnaces can be carried out at the minimum cost and with the smallest amount of transport, and the subject is illustrated by numerous plans to make clear the questions of good and bad practice involved. Similarly, the different arrangements for the buildings and the position of the plant in them are discussed each in their order, but here the only criticism which can be made is that the subject is so extensive that only a sketchy outline can be given in the pages at the author's disposal. The main principles determining the various factors are given; about each of them a volume as large as the present book could be written with profit.

On glancing over building sections illustrated in this volume one cannot but notice how much more appropriate to the required purposes are the types of roof truss employed by the German works when compared to the triangular roof truss which seems to have been standardised for all buildings, by ourselves and the Americans. The artistic outside appearance which one remembers as such a feature of the best modern works on the Continent is surely not the only advantage which this type of construction possesses.

In steel production the melting furnace is the most important detail of the plant, and it receives in the section devoted to its consideration here very adequate treatment. There is much data collected together of the greatest use to those who are concerned with the design and working of melting furnaces. Comparisons which the author makes in the dimensions of furnaces in British, American and Continental practice bring out clearly the shallowness of the bath in foreign practice, and if those in this country who are constantly referring to the mystery of the slowness of working our charges when compared with the rapidity in German practice would remember this fact, they might not have so much then to disturb their mental peace.

The remainder of the book is taken up with sections on producers, charging machines, crane arrangements, waste heat boilers and all those secondary improvements which can determine nowadays the balance between profit and loss. Altogether this is an excellent book and one which it is to be hoped will soon be available in an English translation.

Generalised Linear Perspective, Treated with Special Reference to Photographic Land Surveying and Military Reconnaissance. By I. W. GORDON. London: Constable and Co., Limited. [Price 21*s.* net.]

IN this volume the author attacks and claims to have solved a problem that offers many practical difficulties. His object is to derive from the photographed pictures of a considerable area, a true geometrical representation exhibiting correct contour lines. The photographs are taken from an unknown position, as from a balloon, with a lens whose optical axis makes any angle with the object photographed, both in tilt and in azimuth. There may be arrangements for so weighting the camera that it takes a vertical position when hung pendulum-wise, but this is nowhere stated, and the angle of tilt is one of the unknowns that is to be derived from the photograph. The optical centre and the focal length of the lens, supposed invariable, are known, and measurements supply the remaining data. The general problem is regarded as a generalised system of perspective, and it is contended that a successful solution must go far to abolish the use of the theodolite and plane table. This is a revolutionary notion to which we are not prepared to subscribe. Photographic surveying has not proved a great success, though much care has been lavished on the construction of the apparatus, with the view of reducing the problem to its simplest terms and of giving satisfactory results to the observer with the least possible trouble. It is true that in the capable hands of Colonel Laussedat and Captain Deville very useful results have been obtained, but the older methods retain their favoured position in spite of competition. The addition of a balloon to the equipment of the explorer or surveyor does not make the adoption of the plan more hopeful, and the extra training required is a distinct drawback. The hope of getting a satisfactory result must have appealed strongly to the officers of all the belligerent armies when engaged in military reconnaissances from aeroplanes, but notwithstanding that the urgency of the motive led to much diligent study, it is asserted that no progress was made in solving the problem.

Viewed from either the practical or theoretical side the plan is not novel. Colonel Laussedat, so ardent an advocate of photographic surveying from a fixed station, did actually succeed in constructing a few topographical maps by the aid of balloon photography, but abandoned the plan, preferring the results derived from the use of a station camera. As this early attempt was made about fifty years ago, he probably had trouble from the spherical aberration of his lens. Mr. Gordon cuts out all such difficulties by treating his picture as formed by a pinhole camera, but practically, distortion cannot be regarded as negligible. The history of the theory is not uninteresting as it shows that the problem has been attacked more than once, the conclusions remaining unused and forgotten. We can sympathise with the author on finding that he had been forestalled in his inquiry, and can congratulate him on bringing to light a completely satisfactory solution furnished more than 200 years ago by no less a mathematician than the author of "Taylor's Theorem." That Taylor wrote a book on perspective is well known, and it passed through several editions, but Mr. Gordon learnt of the existence of the treatise accidentally and believes that it has not been widely read. This conjecture is probably accurate, and the reason usually assigned is that Taylor's style is compressed and obscure, an assertion which the author generously confutes. Some fifty years after Taylor, Lambert, in considering the same or a similar problem, also correctly determined the theoretical principle, upon which perspective pictures may be utilised for topographical surveys, but the proof is not mentioned here, and as the work is only known to the present writer by repute, no reason can be assigned for its neglect or supersession. Since at either of these dates no photograph existed and consequently no prospect of practical application, the inquiry was an exercise in pure science "wrought as the devotees of knowledge work their material, to the roundness of a systematic whole."

Only the conception of the problem presents any difficulty, the mathematics are quite simple, yet it is doubtful if the practical application of the formulæ has been correctly understood. To apprehend the process thoroughly and to decide on its feasibility, it is necessary to go through the work of identifying measuring, verifying and plotting the details. This is a stern but necessary discipline, and it would be impertinent either to approve or to reject a scheme from simply reading the description. There are, however, some points which are insufficiently explained. As a preliminary it would seem to be necessary to project some figure, a rectangle preferably, on the ground to be surveyed, always a difficult undertaking, and one that could hardly be effected within an enemy's lines. The author's alternative was to project a regular beaconed base into the photograph, but fortunately Taylor's formula avoids the difficulty, since it permits the horizon to be identified by the four points of a level quadrilateral of known dimensions, whatever its shape. In the fully-worked-out example of a chain of photographs supplied by the Air Ministry, the necessary dimensions of the figures have been taken from the Ordnance Survey Map, and here again in working in an unknown country, with no maps available, the application of the method would be attended with very great difficulty.

Contour levels also call for some subsidiary aid, and the author suggests the comparison of two photographs of a doubly-photographed area. Unfortunately, as no contour lines are drawn on the specimen plans we are unable to judge of the facilities or of the accuracy with which these indications of change of level can be inserted. The photographs used for illustration did not lend themselves to the purpose of contouring, as the camera stations were high, nearly 4,000 ft., and the differences of level on the ground photographed amounted to only about 1 per cent. of this quantity. For such delicacy, paper prints were quite unsuitable, the accidental stretching of the paper being sufficient to mask the evidence of irregularity.

This remark tempts one to ask what degree of accuracy generally may be expected in linear measurement. Mr. Gordon has applied the actual test of measurement to some of his deductions and decides that in the most favourable cases the errors are surprisingly small, and do not exceed "one-tenth of 1 per cent. when compared with the corresponding measurement taken on the Ordnance Survey Map." Unfortunately, there are some errors or deviations greater than this quantity. These are due to the fact that the surface measured faced the camera on the side of a steep hill, revealing a contour which the Ordnance Map failed to show. But in actual work on unknown ground, it is not easy to perceive how such conditions could be avoided. It might, however, be possible in some situations to use devices corresponding to stadia work, a possibility that the author does not discuss, though he proposes to use horizontal and vertical beacons. Another point of practical importance is the time occupied in constructing the diagram. The author found the identification of the projections on the Ordnance Map a very tedious business, occupying several hours of work, but having effected this stage, the remainder of the work could be accomplished in half an hour. This, he contends, compares very favourably with the time required to reduce the materials of a plane table survey.

BOOKS RECEIVED.

Elektrotechnik Einführung in die Starkstromtechnik. Part IV. *Die Erzeugung und Verteilung der Elektrischen Energie.* By J. HERRMANN. Berlin and Leipzig: Walter de Gruyter and Co. [Price 1*s.*]

Directory of Paper Makers of the United Kingdom, 1923. London: Marchant Singer and Co. [Price 5*s.* net.]

Belt Conveyors and Belt Elevators. By FREDERIC V. HETZEL, M.E. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 25*s.* net.]

Principles of Engineering Drawing for Technical Students. By CHARLES C. LEEDS, B.Sc. Second edition, revised and enlarged. New York: D. van Nostrand Company. London: Scott, Greenwood and Son. [Price 10*s.* 6*d.* net.]

Medical Research Council. The Kata-Thermometer in Studies of Body Heat and Efficiency. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 5*s.* net.]

Special Steels. A Concise Treatise on the Constitution, Manufacture, Working, Heat Treatment and Applications of Alloy Steels, Chiefly Founded on the Research regarding Alloy Steels of Sir Robert Hadfield, Bart. By THOS. H. BURNHAM, B.Sc. London: Sir Isaac Pitman and Sons, Limited. [Price 5*s.* net.]

Motor Boats. A Review of the Development and Construction of Marine Motors and Motor Boats. By F. STRICKLAND, M.I.Mech.E. London: Sir Isaac Pitman and Sons, Limited. [Price 3*s.* net.]

Wireless Telephones and How they Work. By J. ERSKINE-MURRAY, D.Sc. Third edition, revised and enlarged. London: Crosby Lockwood and Son. [Price 4*s.* 6*d.* net.]

Costing and Price Fixing. By J. M. SCOTT-MAXWELL, B.Sc. London: Sir Isaac Pitman and Sons, Limited. [Price 6*s.* net.]

Technical Analysis of Steel and Steel Works Material. By FRANK T. SISCO. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 25*s.* net.]

Machine Tools and Their Operation. Part I. *Lathes, Drills and Drilling, Hand and Automatic Screw Machines, Screw Machine Tools and Boring.* By FRED. H. COLVIN and FRANK A. STANLEY. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 20*s.* net.]

Machine Tools and Their Operation. Part II. *Planers, Shapers, Slotters, Broaching, Milling, Gear Cutting and Grinding.* By FRED. H. COLVIN and FRANK A. STANLEY. First edition. London: McGraw-Hill Book Company, Limited. [Price 20*s.* net.]

Problems in Machine Design. By O. A. LEUTWILER, M.E. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 7*s.* 6*d.* net.]

Die Bagger und die Baggereihilfsgeräte Ihre Berechnung und ihr Bau. Vol. I. *Die Nassbagger und die dazu Gehörenden Hilfsgeräte.* By M. PAULMANN and R. BLAUM. Second edition. Berlin: Julius Springer. [Price 20*s.*]

INDUSTRIAL NOTES.

WE referred on page 629 *ante* to a ballot being taken by the railway shopmen with regard to the further cuts proposed in the war bonus. It is stated that following upon the result of this ballot, the unions concerned have rejected the proposals made by the railway companies. These proposals were for an immediate reduction of 2*s.* per week, followed by two of 1*s.* each at later periods. The figures of the ballot have not been made known, and the natural inference to be drawn from this fact is that they show the usual high proportion of absentees. In this connection, it is interesting to record the following statement made in the quarterly report to March 31, recently issued by the Associated Blacksmiths' and Ironworkers' Society:—"The threat of the National Union of Railwaymen to withdraw all their members in the event of any reduction in shopmen's wages is, we are assured by those in daily contact with members of that Society, bluff, undertaken with the obvious intention of strengthening that organisation numerically; but shopmen generally are not so readily hoodwinked, and this, we are satisfied, they will confirm at no distant date."

The United Society of Boilermakers and Iron and Steel Shipbuilders has been expelled from the Engineering and Shipbuilding Trades Federation, by reason of the society's refusal to honour the overtime and night-shift agreement by which they were bound as forming part of the Federation. At the end of last week, the society telegraphed to the Employers' Federation asking for a meeting with a view to discussing the points in dispute. This meeting was fixed for Wednesday, the 30th ult.

The colliery enginemen, stokers and mechanics held a conference a few days ago in Swansea, when a motion to seek the best terms of amalgamating the Enginemen's Federation with the Miners' Federation was rejected. According to an official statement issued at the close of the conference, the enginemen were willing to co-operate nationally or locally with the miners, provided their own rights of organisation and negotiation in their own interests were respected.

A deputation from the Parliamentary Labour Party waited on the Prime Minister on Tuesday evening, to ask him to grant facilities for a discussion in the House of Commons of the Coal Mines (Minimum Wage) Amendment Bill which was introduced early in May by Mr. Adamson. In his reply, the Prime Minister stated that he recognised the need for a full and early public discussion, but owing to congestion of Parliamentary business, the only way in which this discussion could be carried out would be by the Labour Party arranging to forego one of its allotted Supply days. If this were given effect to, he would have no objection to a discussion either on the Bill or on a resolution which the Labour Party might decide upon after discussion among its members. The Miners' Federation conference opened at Blackpool on the following day, Wednesday last. We hope to report upon its proceedings in our next issue.

Mr. Straker, one of the Miners' Executive, is reported to have stated that the issue to be decided at the Blackpool conference was as to whether or not the miners should endeavour to amend the national agreement or give the necessary three months' notice to end it. In his opinion, the latter course would be the greatest blunder of all the blunders of which the Miners' Federation has been guilty during recent years. He regarded the national agreement as the only set-off the Federation had against these blunders.

The National Wages Agreement, we may add, was arrived at in the first week of July, 1921, and whilst it restored the District Conciliation Boards and the district standard wages, it granted new measures and provided for a National Wages Board formed of representatives of the owners and workmen in equal numbers, presided over by a neutral chairman. The agreement stipulated that wages and profits were to rise and fall together according to a determined scale, and established a minimum wage.

Speaking in Biddulph, Staffordshire, last Saturday Mr. F. Hodges, secretary to the Miners Federation, said that the situation in the coal industry was exceedingly serious. In regard to the existing agreement between the owners and workmen, he referred to the mistaken opinion prevailing amongst a certain number of the latter, to the effect that it was entirely responsible for the existing situation, whereas the anomalies within the industry were great and of long-standing. For the most part the anomalies were natural and geographical. They could not be straightened out by strike action. Two methods were open, voluntary co-ordination among the owners so as to eliminate as far as possible natural inequalities, or in the absence of such voluntary action, Parliamentary or Government action by nationalisation, or alternatively by fathering the "Miners' Wage Act Amendment Bill," so as to provide a living wage for the workmen consistent with the cost of living. He urged the miners to concentrate upon the Parliamentary method rather than upon the strike method.

The coalowners have replied to the complaints made to the effect that although the coal output has been at a high level since the beginning of the year and prices have risen, wages have not kept pace with the increase in output and price. The reason, they state, is that, at the urgent request of the miners' leaders themselves, the ascertainment periods were altered from one month to two, there being two months' interval before the new rate comes into force. The miners are not content to await the effect of the admitted improvement in the industry upon their wages, but are demanding that the whole policy of the coalowners—in keeping prices as low as possible in order to stimulate demand, absorb unemployment, and restore national prosperity—should be changed, and prices fixed according to arbitrary and uneconomic standards, having no relation to what the industry can bear.

Speaking at the annual general meeting of the shareholders of Pease and Partners, Limited, Sir Arthur F. Pease, the chairman of the company, said that the total wages paid by Pease and Partners and the affiliated concerns during the year were 2,317,000*l.* The total amount of dividend and debenture interest paid to the public was 179,341*l.*, or only 7·74 per cent. of the wages paid. The total amount paid in local rates was 135,736*l.* Some years ago there were nearly 13,000 employees and about 4,000 shareholders; there were now over 22,000 workmen and over 7,000 share and debenture holders. Sir Arthur further stated that he could not understand the great reluctance of the men to work slightly longer hours, which would inevitably increase the rate of wages; neither could he understand how men who were pleading that they had not a subsistence wage could voluntarily take an unrecognised holiday on May Day, whereby those in Durham directly lost about 80,000*l.* for one day.

According to returns issued by the Board of Trade, the tonnage of coal raised and weighed at the pit during the first quarter of this year was 71,043,000 tons, as compared with 68,760,000 tons during the last quarter of 1922, and 62,202,000 tons during the first quarter of last year. Coal was wound at the pits on 70·73 days during the first quarter of this year, or 5·44 days per week, as compared with 5·35 days per week in the last quarter of 1922, and 5·14 days in the first quarter of 1922. The output of coal during the last quarter of 1922, according to actual ascertainments, was 18·10 cwt. per shift worked, and from such indications as are at present available, this relatively high rate of output under existing conditions appears to have been maintained during the first quarter of this year. The quantity of coal shipped abroad, either as cargo or for the use of vessels engaged in the foreign trade, during the first quarter of this year was 23,263,000 tons; the figure for the last quarter of 1922 was 23,414,000 tons, and that for the first quarter of 1913, 22,187,000 tons. The average earnings for workers of all classes and ages amounted to 9*s.* 5½*d.* per shift in the last quarter of 1922, and it is estimated that earnings rose to 9*s.* 8¾*d.* per shift in January and February of this year and fell to 9*s.* 6¼*d.* per shift in March. The total cost of production per ton of coal disposable commercially in the first quarter of this year was 19*s.* 9·66*d.*, in which wages entered for 13*s.* 4·08*d.* The proceeds of commercial disposals were 20*s.* 9·90*d.* per ton.

The Connecticut Manufacturers' Association, says *The Iron Age*, New York, has completed a survey of the labour situation in foundries of that State since 1913. It shows that earnings of common labour employed in jobbing foundries making grey iron castings where union labour is employed, have increased by 93·3 per cent. since 1913. During April last, the average weekly earnings of moulders and core-makers were 125 per cent. greater than in 1913. Cupola tappers in some foundries received the greatest increase in wages. In 1913, this class of labour was paid 2 dols. a day, or 12 dols. a week. In the war peak period cupola tappers received 7·20 dols. a day or 43·20 dols. a week, an increase of 260 per cent. Few apprentices are now employed in union foundries. Out of a total of 277 employers of all kinds at all plants, only four core-makers and three moulders are working as apprentices. The same journal reports that the United States Department of Labour, with reference to wages and hours of labour in representative sheet mills, says that the average earnings per hour in this branch of the iron and steel industry in 1922, as compared with 1920, show a decrease of 36 per cent.; as compared with 1913 an increase of 47 per cent., and as compared with 1910 an increase of 75 per cent. Rollers in 1922 earned 82·84 dols. per week for an average of 43·8 hours; and 129·10 dols. in 43·4 hours in 1920.

"THE ABOLITION OF EUCLID."

TO THE EDITOR OF ENGINEERING.

SIR,—I am very glad to see protests—rather belated—in your paper against the dropping of Euclid. The process began soon after the school-days of the generation now holding senior positions in science and engineering, by the introduction of "Bowdlerised" versions in which Todhunter's carefully worded translation was chopped about, important steps in the logical argument were omitted, and students were encouraged to do funny things with a ruler and compasses. From this it was an easy stage to dropping the study entirely.

From the point of view of pure geometry, nobody claims that Euclid's system is the only way of attacking a problem, but it is undeniably the most thorough. As the knowledge of the student increases he can be allowed to follow his natural inclination and take short cuts, but it is dangerous to do so without full appreciation of the liberty taken.

As a training for the memory, Euclid was very valuable—but *not* when regarded simply as something to be learnt by heart, as unfortunately most masters and many students did regard it. Euclid was useful in proportion as one realised how easy it is to remember anything that one understands, in which the successive points are connected by a logical train of thought.

It was, however, as an exercise in pure logic that Euclid was most useful. Logic as a subject of separate study had dropped out a considerable time previously, and now that Euclid has gone, no form of methodical reasoning is taught in schools.

Yours faithfully,

May 25, 1923. S. E. GLENDENNING.

"THE SUPPLY OF FOREMEN."

TO THE EDITOR OF ENGINEERING.

SIR,—Your article of the 18th is most welcome in ventilating an aspect of the relation between academic and constructional experiences which can hardly be emphasised too much or too often. Daily experience with young men from college provides the best answer to the suggestion of "B.M.T." that this subject has been overdone. This young man, like only too many college professors, is still necessarily in the position of the spinster who lays down her rulings about motherhood.

For myself, with more than a quarter-century of constructional work since my college days, it is still ever-increasingly obvious how college training can be of comparatively little use *unless preceded*, as you describe, by a full course of manual practice. There is no other way of understanding the workman except by working with him with one's own hands. Without this, the youth who listens to lectures cannot possibly visualise his subjects sufficiently to get proper benefit. The condition of such after the usual sequence of public school merely plus college, is pathetic in its superficial smattering for which so much of his own time and his parents' money have been expended.

Again, the professors themselves can hardly realise this condition, for if they had ever been successfully experienced engineers then how could they be expected to revert to professorships? I confess that this is a standing puzzle to me.

To sum up by a rough suggestion: To complete the "three R's" with some drawing, history, and the grammar of English and Latin at 15 years, have one year in carpenter's shop, and then two years on steel work or other construction. At 18 go to college for two years, and get on the real productive work with salary not later than 20. After all, one can learn best by *living* one's work rather than by listening or reading about it, and one's education in engineering must continue throughout the whole of one's engineering life.

Yours faithfully,

F. W. DUCKHAM.

146-7, Grosvenor-road, London, S.W. 1.
May 29, 1923.

PNEUMATIC GRAIN ELEVATORS.

TO THE EDITOR OF ENGINEERING.

SIR,—Your very full article on the subject of the new floating pneumatic grain elevators for Messrs. Spillers and Bakers, Limited, will remind many of your readers interested on this subject beside myself how no reference by acknowledgment seems ever to be made to the name of the original patentee, the late Mr. Frederick Eliott Duckham, M.Inst.C.E., or to the first constructors who so ably collaborated with him—The East Ferry Road Engineering Company.

The merest comparison between your drawings published last week with those which you published on January 29, 1897, would enable them to realise the originators, and how closely general practice has kept to the salient devices of Mr. Duckham's original system.

Yours faithfully,

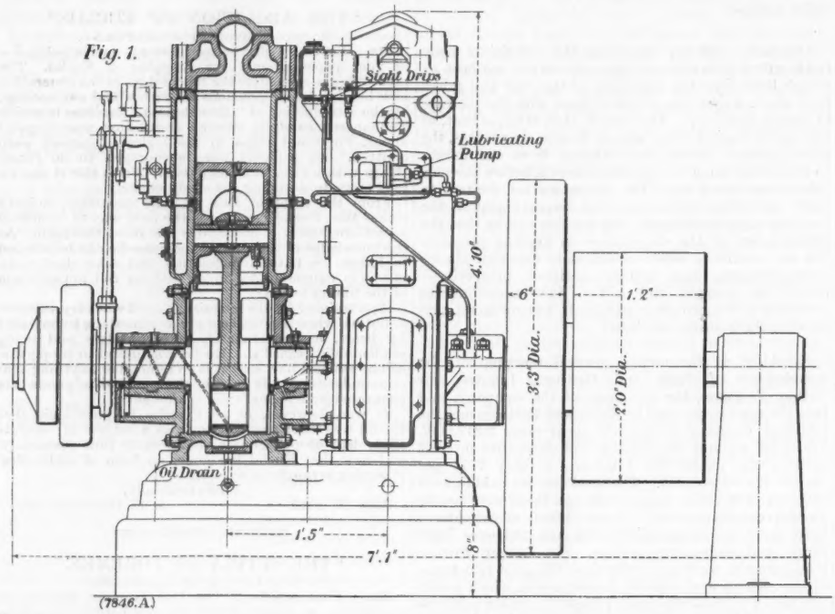
ANON.

MANGANESE ORE FROM BRAZIL.—The total exports of manganese ore from Brazil in recent years have been as follows: 340,706 tons in 1922; 275,694 tons in 1921; 453,737 tons in 1920; 205,725 tons in 1919. These compare with 122,300 tons in 1913.

HOT-BULB OIL ENGINES WITH COLD-STARTING DEVICE.

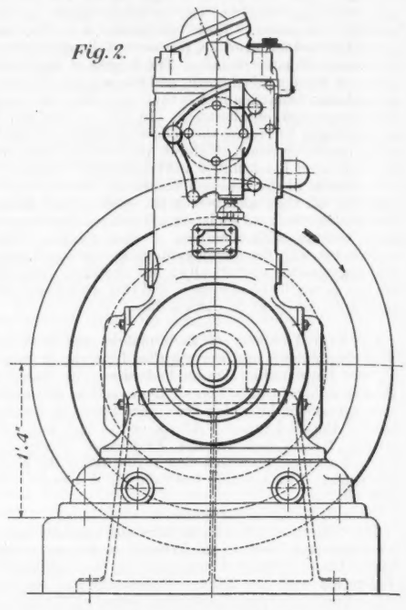
CONSTRUCTED BY MESSRS. PETTERS, LIMITED, ENGINEERS, YEOVIL, SOMERSET.

Fig. 1.



(7846.A.)

Fig. 2.



AMONG the exhibits of Messrs. Petters, Limited, of Yeovil, at the Bath and West of England Agricultural Show, recently held at Swansea, was a 36-h.p. twin-cylinder, two-stroke, hot-bulb oil engine which we illustrate in Figs. 1 and 2 on this page. This engine will run satisfactorily on crude or refined petroleum, and the fuel consumption is given as about half-a-pint per brake horse-power per hour; the normal speed is 450 r.p.m. Fuel is injected by pump, the time of injection, as well as the quantity of fuel, being regulated in accordance with the load by the shaft governor seen on the left of Fig. 1. We understand that the engine will run satisfactorily at no load for long periods without any adjustment, the bulb remaining sufficiently hot to ensure complete combustion. In most engines of this type it is necessary to employ secondary injection to keep the bulb hot when working at less than about one-quarter full load.

The pistons, which are 8 in. in diameter and have a stroke of 9 in., are of hard, close-grained cast-iron, and are each fitted with four gas rings and one oil scraper ring, while the connecting rods are drop forgings of high-tensile steel. The crankshaft is also a high-tensile steel forging, machined all over, ground on wearing surfaces and fitted with balance weights. The main bearings are of gun-metal with white metal linings and are ring lubricated, as shown in Fig. 1. Oil also flows from the main bearings through a passage in the crankshaft and webs to the crank pins, as will be clear from the illustration, the supply being maintained from reservoirs mounted near the tops of the cylinders and fitted with sight drips. The cylinders and pistons are lubricated by means of a differential oil pump operated by the scavenging air from the crank case. The pump injects a small quantity of oil into the cylinder at each revolution, the oil entering through tubes passing through the water-jackets as shown in Fig. 1; the delivery pressure of the oil is about 60 lb. per square inch.

Engines similar to that illustrated but with single cylinders are made in four sizes developing 5-h.p., 8-h.p., 12-h.p. and 18-h.p., while the twin-cylinder engines develop either 24-h.p. or 36-h.p. The single-cylinder engines can be started by hand, using a starting lamp to heat the bulb for a few minutes, but a compressed-air starter is supplied with the twin-cylinder engines. In this connection we may mention, however, that Messrs. Petter have recently produced a new form of starting device which is now fitted to these engines, and enables them to be started immediately from cold without using a lamp or employing any electrical apparatus. The device, which is illustrated in Fig. 3, consists of a paper cartridge, measuring 2¼ in. long by ⅜ in. in diameter and containing a combustible, but non-explosive, material which can be placed in the steel holder as shown. When this has been done, the cartridge is ignited by a match and the holder is screwed into the vaporiser of the engine. The engine can then be started immediately in the ordinary way and with the normal running fuel, heat for vaporising the latter being supplied by the combustion of the cartridge until the vaporiser itself has become sufficiently hot for the engine to function in the usual manner. We should also mention that the cylinders of these engines are fitted with a half-compression cock to facilitate the operation of turning for starting up. The position of the cock is such that when it is opened, the gases in the cylinder escape during the first part of the up stroke of the piston, but the opening of the cock is covered by the piston for the later part of the stroke, so that the remainder of the charge is compressed. The cock is, of course, closed as soon as the engine commences to fire.

FIG. 3.

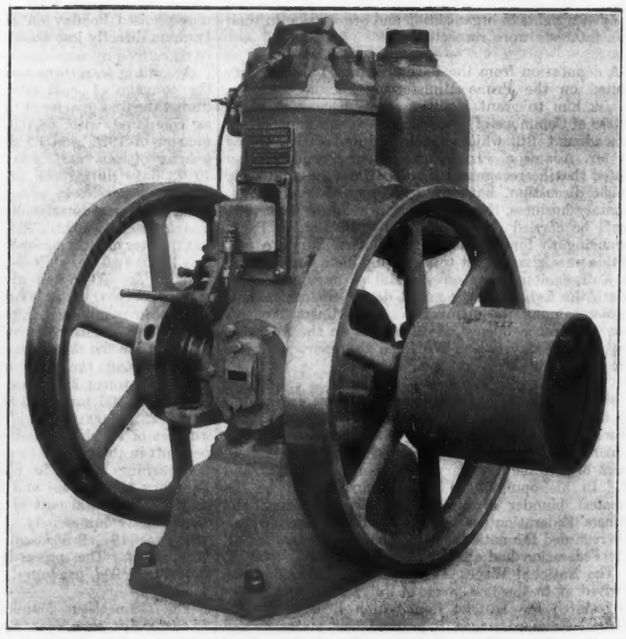


FIG. 4.

Fig. 4 illustrates the appearance of an 8-h.p. single-cylinder engine of the same type, also shown at the above-mentioned exhibition. In this engine, the bore of the cylinder is 6 in. and the piston stroke 5¾ in., while the normal speed is 550 r.p.m. It is fitted with two flywheels 26 in. in diameter and with a belt pulley 10 in. in diameter by 10-in. face. In general, the design of the engine is similar to that illustrated in Figs. 1 and 2 and described above, but we may mention that, in the smaller engine, the silencer is mounted directly on the exhaust outlet at the back of the cylinder, as shown in Fig. 4. The firm also exhibited small engines fitted with magneto ignition and suitable for petrol, paraffin, alcohol and other fuels, as well as small marine oil engines, electric-lighting sets, oil engine-driven pumps, portable oil engines, etc.

APPOINTMENT OF ENGINEER FOR AUSTRALIAN NAVY.—We understand that Engineer-Captain E. D. Sydenham, has been appointed to the Royal Australian Navy, and that he will be the senior engineer officer on the active list of the Commonwealth Fleet.

CASTING HARD ROLLS.

IN the general study of the methods of chilled casting, the relative rates of cooling of the ingot and of the mould have received comparatively little attention. As a consequence the practical rules as to the thickness of the mould suitable for rolls of various kinds are more a matter of custom than of experimental investigation, though it is clear that rules for the casting of long rolls of small diameter, wanted for printing and for textile machinery, will hardly be applicable to the stout, very heavy rolls which sheet-metal and plate mills require. Paper rolls, *i.e.*, rolls of the first of these two classes, should have a very homogeneous, very hard surface free of pores, whilst in rolls for stout plating great resistance to fracture is the primary requisite. Paper rolls may weigh as many pounds as plate rolls weigh tons; the Grusonwerk of Krupp has made rolls of 33 tons weight. The rolls used for making fine sheet metal may be allowed to run hot; the rolls for stout plates must be water-cooled. In the former, as in the paper rolls, high

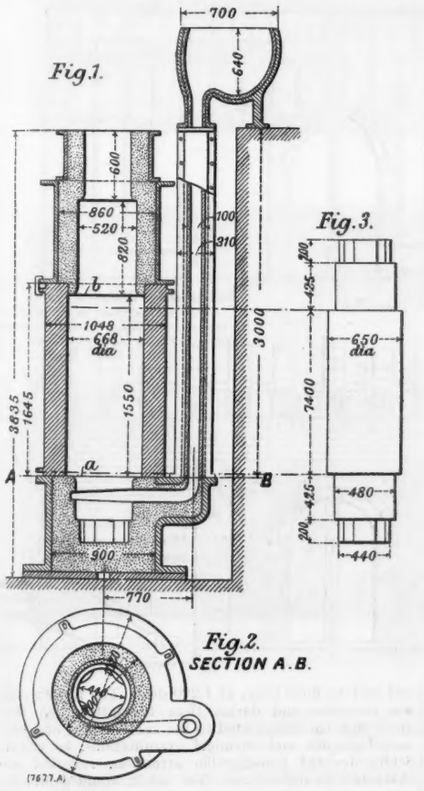


Fig.2. SECTION A.B.

surface hardness is essential; the surface hardening of plate rolls should not be pushed too far, lest surface particles split off in the mill. For these reasons both the material and the mode of chill-casting have to be adapted to the purpose in view.

As the metal fills the mould, the mould heats and expands; then the ingot will begin to cool and to shrink, ingot and mould are no longer in contact, and the conditions of the heat transference from the one body to the other undergo a change, which will depend upon the relative dimensions of the two. In paper rolls the usual ratio of the ingot diameter to the wall thickness of the mould is about 1 : 0·5; in metal rolls about 1 : 0·28. Some metallurgists try to intensify the quenching effect of the metal mould by increasing the mould thickness. According to the studies of Dr. Ing. Emil Schüz, this is not generally advisable, and his paper on "Casting Chilled Rolls" (reproduced recently in *Stahl und Eisen*) also helps to explain why the moulds will crack within the first six minutes after pouring, if they crack at all, and to account for some other peculiarities known to steel-foundry men.

Schüz experimented with 38 rolls; the metal of eight of these was obtained from a reverberatory furnace; in the other cases cupola metal was mixed with the other metal in order to raise the total carbon percentage above 3. The experiments had to be conducted in such a way as not to spoil the rolls. A diagram of the general arrangements of the mould ready for casting is given in Figs. 1 and 2; Fig 3 shows the finished roll. The roll, 650 mm. (25·5 in.) in diameter, and 1,400 mm. (55 in.) cylindrical length, is poured standing in a cast-iron mould of 668 mm. internal diameter and 190 mm. (7·5 in.) wall-thickness; there are thus 18 mm. (0·67 in.) left in the roll diameter for shrinkage and for finishing. At *a* the solidified roll rests on the sand mould; this section *a* would contract horizontally, but would not undergo any vertical shrinkage movement, whilst the upper section *b* would vertically move through a distance corresponding to the whole vertical shrinkage of the roll. There was thus some difficulty with regard to fixing the thermo-couples for obtaining the cooling curves; Figs. 4 and 5 explain how this was overcome. The thermo-couples to be inserted into the roll had to be taken through holes bored through the mould, but these holes had to be kept closed as long as the metal was liquid. The hole was therefore closed on the inside by a metal plate, 2 mm. in thickness, which a spiral spring attached to an arm pulled tight against the inside of the mould. The sheath of the thermocouple, a quartz tube, penetrated through a hole in this plate into the inner space; when the mould was charged with metal, the plate froze

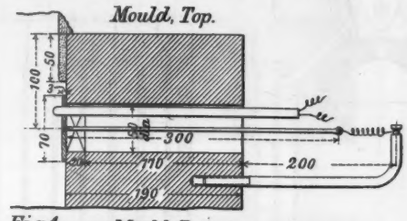


Fig.4.

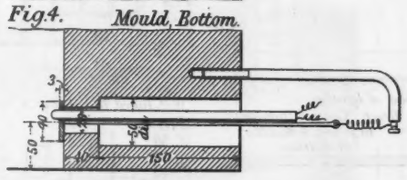
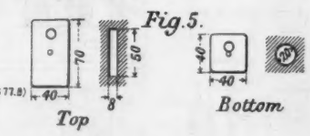
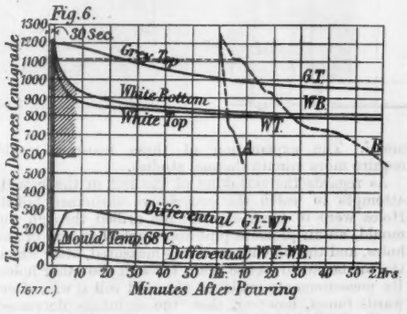


Fig.5.



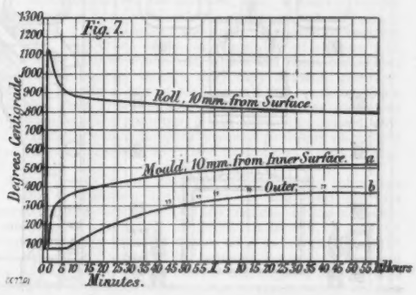


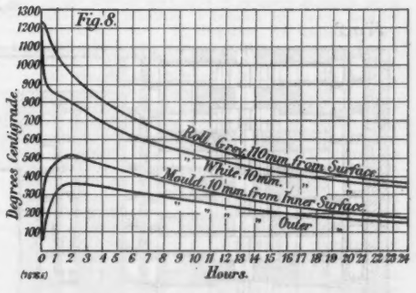
to the metal and took part in the shrinking of the solidifying steel. The upper and lower thermocouples were so mounted as to penetrate about 10 mm. (0·4 in.) into the white hard surface of the roll, which would have a thickness of about 0·8 in.; a third thermo-couple penetrated also, in the upper *b* section, to a depth of 110 mm. (4·3 in.) into the roll, and ended in the grey, unhardened portion of the metal. Simultaneous readings of the 3 millivoltmeters were taken every five seconds.

In this way the curves of Fig. 6 were obtained. The abscissæ mark the time in minutes and hours elapsed after filling the mould, which took 30 seconds; the curves "grey top" and "white top and bottom" mark the temperatures observed in the different portions, and the differential curves the differences between these respective temperatures. The shading indicates the approximate depth to which the quenching effect would extend. It is to be noticed that none of the curves indicates any recalescence; while it is further surprising to see how rapidly the white portion cooled down whilst the grey core, like any large piece of casting, cooled very gradually.

The white metal at the bottom near *a*, being replenished as long as pouring continued, remained hotter than the white metal at *b* near the top; the maximum difference between the two curves amounted to 90 deg. C. The temperature difference between the grey and the white metal increased rapidly, from 90 deg. up to 300 deg., within the first 8 minutes, to decrease gradually afterwards. All the white-metal curves showed a marked change near 900 deg.; the cooling then became slow, because shrinkage had set in, and the roll was no longer in contact with the mould. Fig. 6 further shows, in the dotted curves, the behaviour of two ladle samples of the same metal, poured, the one A, into a small chill mould, the other B, into sand; the former took 8 minutes, the latter 1 hour, to cool down to 550 deg. C. The slow-cooling curve B of the sand casting distinctly marks two periods during which the temperature did not change; in the curve A of the chilled casting those periods are indicated by changes, setting in at the same temperature, in the slope, suggesting changes in the rate of cooling. Solidification seems to have commenced at 1,100 deg. C., and a study of the curves led to the conclusion that the grey core of the roll at a distance of 110 mm. (*i.e.*, one-third of the radius of the core), solidified 27 minutes after the white zone had become solid.

In the further investigation simultaneous tempera-





ture measurements were taken in the mould wall and in the casting, in the former case at points, 10 mm. both from the inner and the outer surface; the curves obtained are reproduced in Fig. 7. It will be seen that the temperature near the inner surface of the mould rose very rapidly for about 5 minutes and then slowly, the change in the rate coinciding approximately with the cooling of the charge; the outer portion of the mould did not show any temperature rise for the first 5 minutes, and the rise was then much more gradual. The heat thus took 5 minutes to travel through the wall-thickness of the mould. Within 10 minutes the temperature difference between the inner and outer portions of the chill had reached its maximum value of about 270 deg. C.; it afterwards diminished very slowly. This shows that matters would have been pretty much the same if the mould had been made much thicker. The reason is largely because the charge and the mould do not remain in actual contact. When samples were cast into a cast-iron pan, with the bottom of which the shrinking charge would remain in contact, the chilled lower zone of this sample was found to have double the thickness of the chilled zone of the roll.

For the further study of the heat-flow through the chill mould, holes were drilled to depths of 10 mm., 63 mm., 126 mm., 180 mm. (0·4 in, 2·5 in., 5 in, 7 in.), the total wall-thickness being 190 mm. (7·5 in.). Thermo-couples inserted in these holes gave curves intermediate between the curves *a* and *b* of Fig. 7, as one would have expected, and the measurements showed a temperature fall, in the wall, from inside outward, which would for the first minutes be represented by a hyperbola, turning gradually into a sine curve. When the mould was preheated to 60 deg. C. before casting, the temperature decreased in the inner-third of the wall-thickness, after casting, by about 200 deg., and this rate of fall remained fairly constant during the first 4 minutes, diminishing subsequently; whilst the temperature fall in the outer-third kept at about 70 deg. for 2 hours. It took 20 minutes before the outer surface of the chill became hot, and about

REFRACTORY MATERIALS IN GAS WORKS.

Fig. 1

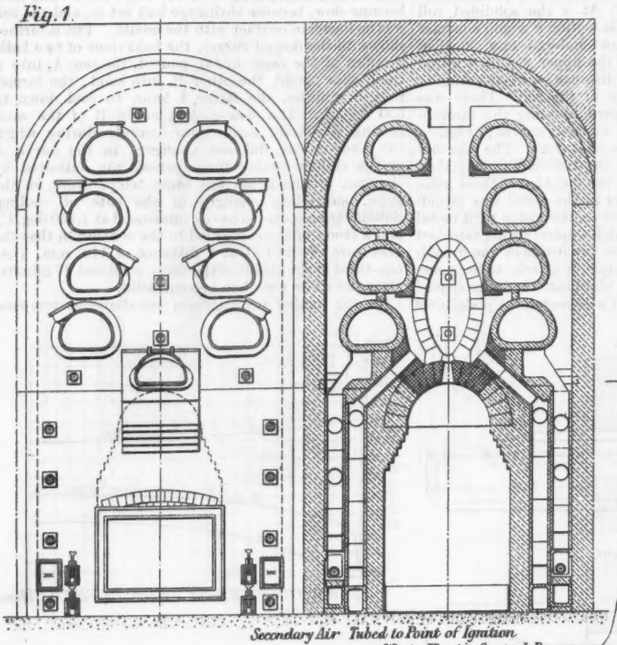


Fig. 2.

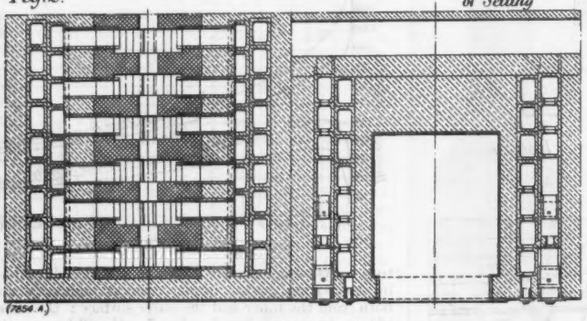


Fig. 3.

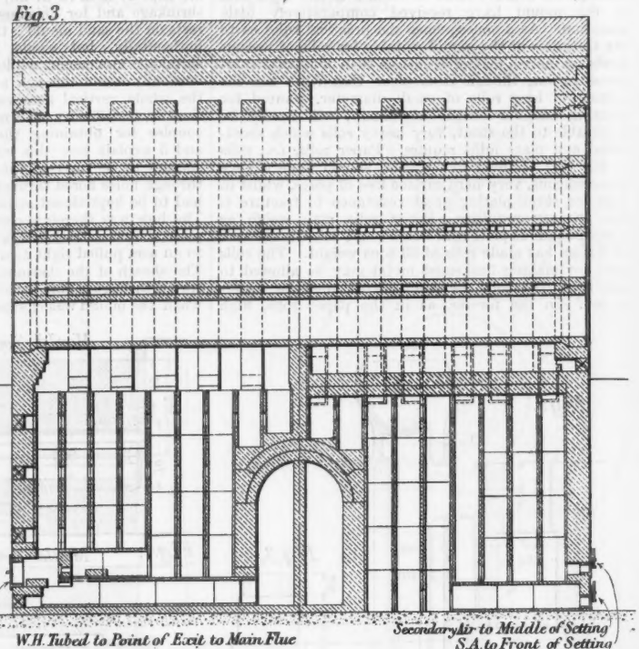
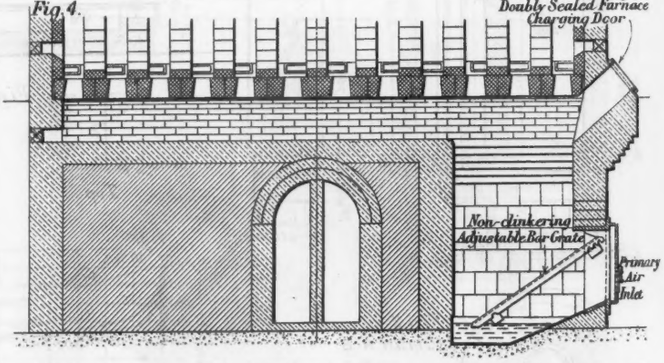

W.H. Tubed to Point of Exit to Main Flue
Secondary Air to Middle of Setting
S.A. to Front of Setting
Doubly Sealed Furnace Charging Door

Fig. 4.



2 hours to establish a constant heat-flow through the chill. Since contact between the contracting roll and the mould would be broken after 8 minutes, during which period only the inner-third of the wall heats up to any noteworthy degree, while the outer two-thirds remain relatively cool, a chill of 60 mm. thickness would practically have the same quenching effect as a chill of 190 mm. thickness gives, and the greater wall-thickness would become essentially a question of strength and durability. The experiments further suggested that a chill mould, being exposed to the most rapid temperature changes during the first 6 minutes after charging, should burst in that period if liable to fail. That agrees with practical experience, and these considerations are said also to account for another trouble of foundrymen. When steel rolls are cast in rapid succession, without giving the mould time to cool, the mould is apt to crack. Schüz argues that if a new hot charge is poured into the mould which is internally still much warmer than externally, the temperature of the internal portion of the mould will rise to a higher degree than it did during the first casting, whilst the external portion of the mould still has the temperature it had after stripping its first roll, and if the casting operation were rapidly repeated, high temperature stresses might arise. Schüz would prefer to cool only the inner portion of the chill.

The results of experiments continued for 24 hours are reproduced in Fig. 8. It is to be noticed that the mould temperature drops off after having attained a maximum of 520 deg. C. in about 2 hours, though the charge inside is still hotter by 300 deg. The mould is cooled by the outer air, whilst the layer of air between the mould and the roll is too poor a heat conductor to replenish that loss. There is further indication of an arrest in the cooling curve of the white metal near 800 deg., but no corresponding arrest in the grey metal. The explanation of these features would require more minute thermal studies.

As regards the shrinking of the roll in the mould, attempts to watch the progressive shrinkage failed. Holes were in these experiments drilled through the mould, an air-pressure pipe was applied to one of the holes, and the time interval was measured, after which the air began to escape again through the other holes. By measurements made on the cold roll it was afterwards found, however, that the shrinkage decreased as the depth to which the quenching had penetrated decreased. Thus when the cylindrical surface had been hardened to a depth of 45 mm., the shrinkage in the diameter amounted to 2·7 per cent.; when the quenching had only penetrated 7 mm. deep, the shrinkage amounted to 1 per cent. The transition of the white into the grey metal being gradual, these depth figures are approximations. The average shrinkage figure was 1·8 per cent.; but that figure changed, of course, with the relative dimensions of the part. A good many of the rolls were subsequently found to be slightly elliptical in section instead of being truly circular; the difference in the diameters amounted to 2 mm. maximum, and that was not connected with the shrinkage figure. In all cases the lower portion of the roll (near *a*, Fig. 1), moreover, turned out to be a little thicker than the top portion (near *b*), and there was a stricture some 4 in. or 8 in. below the top, so that the cold roll appeared doubly conical, and sometimes more irregular; the extreme diameter variations observed were 657 mm. and 662 mm. The hardening had penetrated to greater depths at both the ends of the roll than in the central portion.

Some experiments were finally made on the temperature most suitable for casting hard rolls. Some metallurgists recommend the hottest metal, others give time for a slight cooling. Schüz cast his rolls immediately after teeming, at about 1,320 deg. C., and half an hour later, at 1,220 deg. The former roll was smoother and darker than the latter, but the quenching had penetrated to the same depth, and the metallographic and chemical examinations, to which Schüz devoted considerable attention, revealed no characteristic differences. Yet Schüz would generally recommend casting with the hottest metal coming from the furnace.

THE USE OF REFRACTORY MATERIALS IN GAS WORKS.*

By G. M. GILL.

As is well known the gas industry is a large user of refractory materials. To obtain gas from coal, it is necessary to heat the coal in a closed retort or oven, and the higher the coal is heated the more quickly and the more thoroughly is the gas extracted from it. More than fifty years ago it was customary to use cast-iron retorts, in using which the temperature employed had to be very low compared with that used to-day with fireclay and silica retorts. Coal gas is almost invariably made nowadays in either horizontal or vertical retorts. Inclined retorts, though still used to some extent, have gone out of fashion during the last fifteen years, and a great many of such installations have been pulled out and replaced. Horizontal retort settings may vary in size from those with three single retorts of 10 ft. in length to those having 10 or even 12 retorts of 23 ft. in length, and these settings may be found in the greatest possible variety of design. While the design is a matter of great importance, the question of quality and suitability of refractory materials is probably of even greater importance.

Figs. 1 to 4 show a design of retort setting brickwork, in which eight retorts, approximately 20 ft. long by 23 in. by 16 in., D-shaped, are set in one bed. Such retorts are heated by producer gas from a producer

* Paper read before the Refractory Materials Section of the Ceramic Society at Bournemouth, May 3, 1923.

underneath. The producer gas meets with highly-heated air in the combustion chamber, the products of combustion passing round and heating the retorts, after which these products give up their heat to the incoming air in the regenerator.

A retort has not only to be heated sufficiently to carbonise the coal placed within it, but it has also to be maintained true to shape, level and free from cracks, and holes are required to enable it to be charged with coal and to be emptied of coke, and to give off all its gas without waste. Stoking machinery is somewhat rough with retorts, which need to be tough and durable to withstand their working, and also the contrast in temperature when the retort doors are opened for the hot coke to be pushed out and for a charge of cold coal to be put in. This takes place every 6 hours to 12 hours while the retort is at work.

Fig. 5 shows a type of coal-charging machine, by which the coal is thrown into the retort by centrifugal force, while Fig. 6 shows a retort-discharging machine with

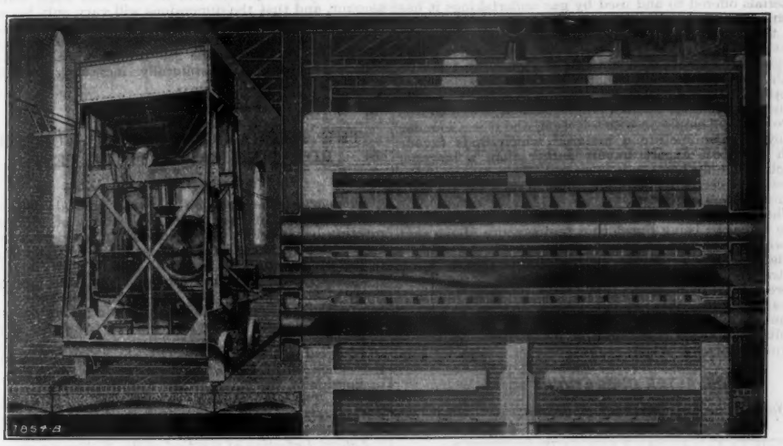


FIG. 5.

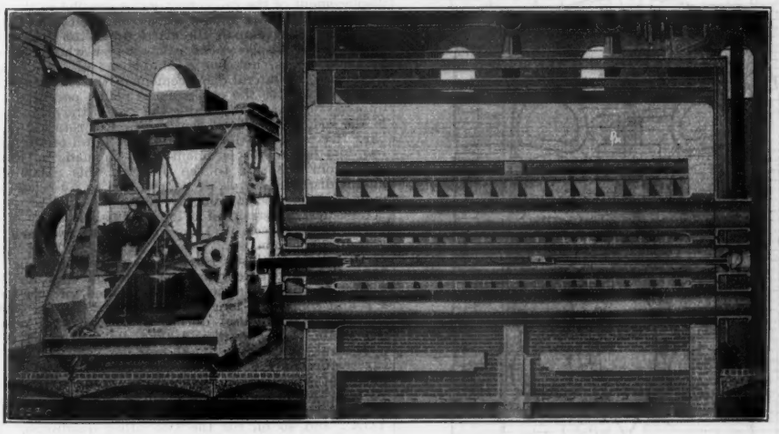


FIG. 6.

Fig. 8.

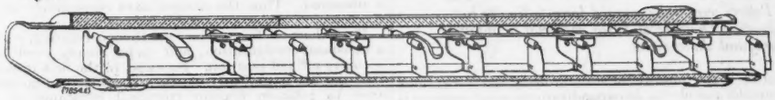


Fig. 7. THE FIDDES-ALDRIDGE DISCHARGING CHARGER.

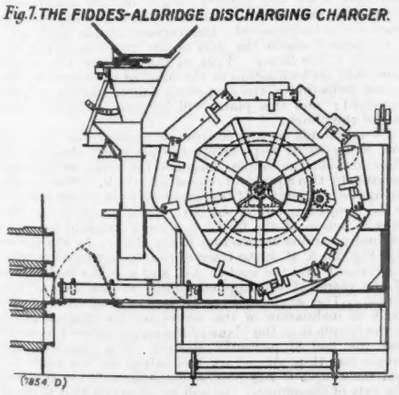
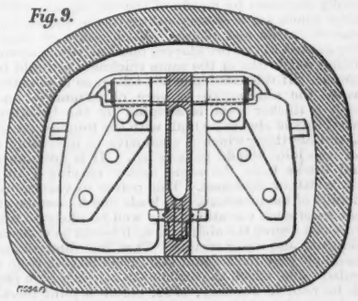


Fig. 9.



ram fully extended throughout the whole length of a retort. This is used to push out the coke—the residue of the coal after gas and liquid products have been expelled by the heat. Fig. 7 shows the Fiddes-Aldridge simultaneous charger and discharger, which machine in one operation discharges the coke from, and charges the coal into, the retort. It will be obvious that to work such a machine satisfactorily the retorts must be kept straight and true. The chain arm of the machine inside the retort itself is shown in Figs. 8 and 9.

Periodically, varying at intervals of a few months to a few years a retort setting will be let down from a working heat to atmospheric temperature, and this process has always a severe effect on the retorts, which develop numerous cracks, all of which have to be stopped up before the retort can again be used. The normal expansion of the retort when heated and the subsequent contraction when cooled account for the presence of these cracks in all retorts after these have once been cooled from a high to a low temperature. In fact, these cracks frequently appear before the retorts have been cooled down, and after the retorts have been "scaled" once or twice. This operation is rendered necessary by the fact that a layer of carbon, known as retort carbon or scurf, grows rapidly on retorts at work, increasing to a thickness of about 1 in. throughout the internal area of a retort in, say, two months' work, sometimes considerably less, depending upon the way in which the retorts are worked. When "scaling" or "scurfing" retorts it is usual to reduce their temperature somewhat, as this causes the carbon to contract and crack, when it is more easily removed with a long chisel bar. The cold air passing through the retort, the removal of the carbon, and the lower temperature of the retort combine to cause its contraction, and, consequent cracking. It must also be remembered that the internal portion of the retort is called upon to withstand a great contrast in temperature, while the external portion is treated to a steady and higher heat, and consequently, a variety of strains are set up in the walls of the retort.

It will, therefore, be realised that a heavy burden rests upon a horizontal retort, and it is not altogether surprising if it fails under the load. Experience teaches, however, that there are a large number of makers who can supply retorts which will withstand these conditions quite satisfactorily, though they may develop innumerable cracks, for a life of well over 1,000 working days, provided that the temperature employed, as measured in the combustion chamber, is not allowed to exceed, say, 1,280 deg. C., which temperature was probably about the maximum employed, with few exceptions, until twenty years ago.

There is one factor, however, which greatly influences a retort's condition throughout its life, and also its length of life, and that is the nature of its support. Assuming that a retort is 20 ft. in length, it will be supported upon walls of 4½ in. to 9 in. thickness, built with spaces of 8 in. to 12 in. between the walls. If these walls remain where built and do not expand or contract, the retort supported thereon has a much better chance of giving a good duty. A retort is naturally flexible to a very small extent only, and it entirely depends upon these walls as to whether it retains its shape and its level and true position. If, therefore, the walls are built of material which expands or contracts to any but a slight extent, the retort cannot possibly give satisfaction. Frequently retorts are blamed for what is the fault of the supporting walls.

Figs. 10 and 11 show the effect of using firebricks which contract at working temperatures, so allowing the retorts to sink and become unworkable. With modern stoking machinery, it is essential that retorts should be maintained in a straight and true level and in their original position as built.

There is a large amount of retort and firebrick material available for purchasers, which will give satisfaction so long as the temperature mentioned above, viz., 1,280 deg. C. is not exceeded in the combustion chambers of retort settings. But the gas engineer of to-day is not satisfied with such a temperature, for carbonising at such temperatures is too slow, and it would necessitate expensive building of new plant to meet the normal increase in gas sales. In working retort settings the author has proved to his own satisfaction, that a small percentage increase in the temperature of carbonisation will allow of a substantial percentage increase in the quantity of coal carbonised in a given time.

In the author's experience, a temperature of 1,280 deg. C. in the combustion chamber of a retort setting is sufficient to carbonise a 10½-cwt. charge of coal in a 20 ft. retort in 12 hours. By increasing this temperature to 1,320 deg. C. the same charge can be carbonised in 10 hours, and by a further increase to 1,400 deg. C., the period can be reduced to 8 hours. That 50 per cent. more coal can be carbonised in a given time by increasing the temperature less than 10 per cent. would seem to be impossible; and, consequently, the author was particularly interested in the figures which Mr. A. H. Middleton included in his paper on "Silica Brick for Coke Ovens," which he read at the Birmingham meeting of the Refractory Materials Section of the Ceramic Society. In this paper, Mr. Middleton recounted a similar experience of a very largely increased quantity of coal carbonised in coke ovens as the result of quite a small percentage increase in temperature. This being so, it must be expected that all the more enlightened gas engineers will be—if they are not already doing so—specifying material for retorts and for the supporting cross-walls, which is capable of withstanding with the minimum possible expansion or contraction temperatures ranging from 1,350 deg. to 1,400 deg. C. under loads as experienced in retort settings. An expansion or contraction of over 1 per cent. from its original size when built, would be calculated to disturb the level of the retorts, and, therefore, this figure should be considered to be the maximum to be allowed.

That material for retorts and the supporting walls should be expected to withstand such temperatures —1,350 deg. to 1,400 deg. C.—for longer periods than those hitherto used, while not expanding or contracting more than 1 per cent. when used for and maintained at such temperatures, must seem very onerous and difficult of achievement. A few makers, however, are producing material which would appear to be able to live up to such requirements, and further, it is material which is capable of showing a much longer retort life than the 1,000 working days mentioned above. Therefore, the gain is twofold, while the duty obtained in tons of coal carbonised per retort life is much increased. The temperatures named,

viz., 1,350 deg. to 1,400 deg. C. are low if the refractory material is to be used with no load placed upon it, but it is quite another matter when the load may be anything up to, or even above, 50 lb. pressure per square inch. Such loads enormously increase the strain under which fireclay material has to do its work, though it is well known that loads have far less effect on high silica or even highly siliceous materials. It is probably true that at the present time not 10 per cent. of the coal carbonised is being dealt with in settings heated to such temperatures, but it is certainly true that far more coal would be carbonised at these high temperatures were the refractory material available to enable such temperatures to be safely employed.

In America, which the author visited three years ago, he found that all the gas works and coke oven works which he visited, numbering some 20 in all, were using such temperatures and were carbonising at a much greater speed than that to which we are accustomed in this country. But all the material used was high percentage silica material. It might be said, why not then at once adopt such material and obtain the great improvement experienced in America? The answer might well be that in this country, there is a large quantity of clay, which, by natural or artificial measures, can be employed to produce refractory materials which have neither the disadvantages of fireclay nor of 95 per cent. silica material. This material, namely, semi-silica or siliceous, may even claim to be the happy medium between the two. Fireclay so frequently shows too much after-contraction and too ready a tendency to soften under load, while 95 per cent. silica material as often shows too much after-expansion, thus compelling the necessity of building in millboard, wooden strips, or of leaving spaces in the setting. Further disadvantages of 95 per cent. silica material are that retorts have to be built up instead of moulded—an expensive alternative—while the tendency of the material to "spall" is objectionable. In the author's opinion, there is great scope for the production of a much larger quantity of semi-silica or siliceous material having a silica content varying from, say, 76 per cent. to 92 per cent. according to the position in the setting and the purpose for which it is required. The same class of material may also be used with great advantage for producer arches and walls, and for the crowns of the arches in horizontal retort settings.

Quite 75 per cent. of the material required for building modern retort settings should be of a quality showing not more than 1 per cent. maximum expansion or contraction at 1,350 deg. to 1,400 deg. C. under load, the remaining 25 per cent. being of a quality showing not more than 1 per cent. maximum expansion or contraction at 1,280 deg. C. under load.

Well-made 95 per cent. silica material of good quality should, in the author's opinion, be used in all cases for combustion chamber arches. He would here also state that the same material, if well and carefully manufactured of a uniform quality, and used for building retort settings with considerable knowledge and experience of its peculiar properties can be employed to great advantage for such purpose. But this is a matter which really needs the combined knowledge and co-operation of manufacturer, and retort setting designer and user, to produce the best results. The author deprecates the idea sometimes put forward that there is no special difficulty in building and working successfully retort settings of 95 per cent. silica material. All the difficulties can undoubtedly be surmounted so long as these are recognised and handled with experience, judgment and intelligence. There will also be required for regenerator chambers a well-made compressed material, without cracks of any sort, which can be safely used in pieces of 1 in. in thickness, for dividing waste gas from secondary air flues. As regards the quality of refractory materials offered to and used by gas undertakings it has often been said that the cheapest tender secures the order, and that under such circumstances, there was no inducement for the manufacturer to improve the quality of his fire goods. There is no doubt that there is a good deal of truth in the statement that the lowest tenders are accepted, but every year, largely as a result of the work of such associations as the Ceramic Society, there will be more who will employ a wise selection, and it is a sounder policy to manufacture a material which finds favour with the most expert buyers rather than a material which sells only because it is cheap. This aspect of the question is certainly becoming more recognised by both manufacturers and users.

The author would here emphasise the essential importance of bricks being burnt to a temperature above that at which they will be used in a retort setting, and so obviate, to a large extent, the after-expansion or after-contraction which is otherwise likely to be experienced. There can be little doubt that bricks burnt at temperatures higher than those to be employed in the combustion chambers of retort settings are more likely to give better results than those burnt at a lower temperature.

Another matter which is deserving of continued consideration is the question of standardising the dimensions of firebricks and blocks, as expenditure on retort settings is materially increased by reason of the sorting and cutting of bricks which are necessary owing to the variations in the size of bricks and blocks. Much waste of time is thereby caused to the bricklayers building retort settings in picking out bricks of the same thickness to build into one course. If this trouble is not taken, as is sometimes the case, the alternative—a very objectionable one—of using a thicker joint is adopted by the bricklayer. Firework should always be built with the thinnest possible joint, and anything which is conducive to increasing the size of the joint should be avoided. It is not unusual to find bricks from the same maker varying $\frac{1}{4}$ in. in length, width or thickness. This points to variations in the details of manufacture, and leads one to assume that the causes of such variations may well be likely to affect in as great a degree the ability of such bricks to withstand temperature and other strains. That the dimensions of bricks do vary by the amount stated can be seen from the appended table, which the author has taken from a paper which he read in January, 1922, before a joint meeting of the Institution of Mechanical Engineers and the Society of Chemical Industry.

Table showing the Maximum and Minimum Dimensions found by examining 24 Firebricks (of each of two well-known makers), chosen at random from a stack of such bricks. The Correct Dimensions should be 9 in. by 4·5 in. by 3 in.:—

	Length. In.	Breadth. In.	Thickness. In.
Maker (A)—			
Maximum ...	9·30	4·56	3·16
Minimum ...	9·01	4·40	2·90
Difference ...	0·29	0·16	0·26
Maker (B)—			
Maximum ...	9·35	4·5	3·12
Minimum ...	8·92	4·27	2·87
Difference ...	0·43	0·23	0·25

Fig. 10. AS BUILT.

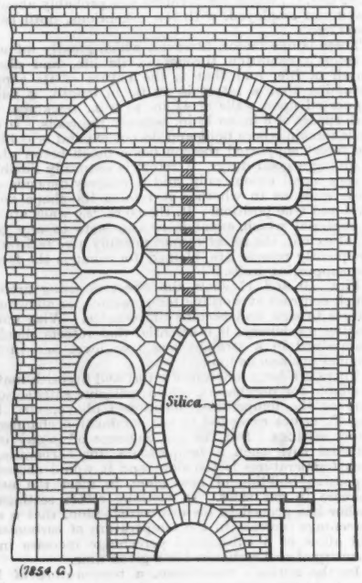
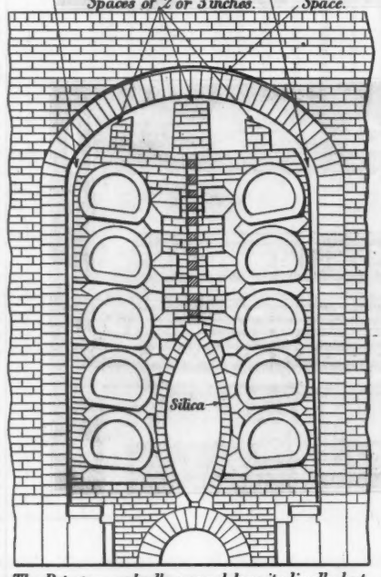


Fig. 11. AFTER OPERATION.

Spaces due to Contraction of Setting.

Spaces of 2 or 3 inches. *Space.*



(7854 G)

The Retorts were badly sagged longitudinally but Combustion Chamber of Silica material maintained its original dimensions.

In conclusion, the author would suggest that there is bound to be a growing demand for fire goods which bear the manufacturer's guarantee that their materials will, upon testing, withstand certain temperatures under definite loads, that the after expansion or contraction under stated conditions will be less than some definite amount, and that the dimensions will vary only between certain stated percentages. This, in the author's opinion, is the step which should be taken by those manufacturers who intend to provide the gas engineer with what he will be requiring in substantially increasing quantities in the near future.

THE MECHANICS OF THE WÖHLER ROTATING BAR FATIGUE TEST.

By Professor W. MASON, D.Sc.

Summary.—The relation between lateral deflection and deflection in the plane of bending of a Wöhler rotating bar is briefly discussed, and an attempt is made to ascertain if there is a constant ratio between lateral deflection and width of hysteresis loop.

Conclusions.—(1) This ratio is determinate for specimens of steel affected only by elastic hysteresis; but for partially elastic or non-elastic conditions the ratio appears to depend on the shape of the hysteresis loop.

(2) The work done on the bar per cycle is shown to be equal to $2\pi G\phi$ where G is the couple imposed on the chuck which holds the rotating bar, and ϕ is the inclination of the plane of this couple to the axis of the chuck. The work done on the bar during the whole, or during any stage of the test may be found if ϕ is continuously measured.

Lateral Deflection of the End of the Wöhler Specimen.—When a load is applied to the end of a rotating Wöhler bar, or when (as the writer has arranged his apparatus) a pair of equal or opposite forces are applied to it, the displacement of the projecting end is parallel to the lines of action of these forces when the forces are small. For loads which impair the elasticity of the material of the bar, the displacement is no longer wholly parallel to these forces, but has a component at right angles thereto. This lateral displacement of the end of the rod is on one side or the other of the plane, parallel to the imposed forces and containing the axis of the gripped end of the rod, according to the direction of rotation of the bar. By reversing the direction of rotation of a fatigued bar, the lateral displacement may be made to change over from one side to the other of this plane. The lateral displacement is, of course, due to hysteresis and may be accounted for roughly, thus:—

Consider the strain of a longitudinal filament of the bar to be composed of (1) cyclic of elastic strain and (2) "cyclic permanent set." Let X′ X Fig. 1*a*, be the trace of the plane of elastic bending—a plane containing the axis of the chuck carrying the specimen, and also containing the lines of action of the imposed force or forces F; and consider a longitudinal fibre of the bar (shown tubular in the figure) during revolution. As regards the strain (1), bending will take place about Y′ Y as a neutral axis. Fig. 1*b* shows the sequence of the (2) strains in the fibre as the bar revolves. In the quadrant XOY (Fig. 1*b*) the strain of this fibre, and of all fibres while in their quadrant, will remain constant, the strain will change sign somewhere in the quadrant YOX′, and so on for the two other quadrants. The neutral axis of strain will be a line in a position such as NN and the lateral displacement due to (2) occurs by bending about NN. If the strains shown in Figs. 1*a* and 1*b* are superposed, the total bending strain of the bar is obtained. Thus the neutral axes respectively of the stress and of the strain are not coincident.

Work done on Bar.—The bar, though rotating, retains a constant configuration, and under steady conditions, occupies a fixed position. Suppose, in the first instance, that the bar is perfectly elastic: there is then no resistance to rotation (except frictional resistance of the bearings), since the applied couple has no component about the axis of the chuck. But now suppose the elasticity to be impaired; the imposed couple must have a component about the axis of the chuck resisting the rotation of the latter. That is, the plane of the couple must shift its inclination in the manner indicated by the lateral deflection of the projecting end of the rod, as just described; and this plane will become inclined to the axis of the chuck.

To treat this in a quantitative manner, let Figs. 2*a* and 2*b* represent respectively the plan and elevation of a bar on which the couple is imposed (as in the writer's apparatus) by two equal and opposite forces F. These forces are applied through ball bearings to a rigid socket secured to the projecting end of the bar. It is assumed that the lines of action of the forces F remain parallel to their original positions as bending takes place. In the elevation Fig. 2*b*, A′ B′ is the trace of the plane which contains the forces F and the socket AB, and ϕ is the inclination of the plane of the applied couple to the axis of the chuck. The angle θ, Fig. 2*a*, is the projection of the angle of inclination of the socket on the original plane of the couple (*i.e.*, the plane of the couple when F is small and the bar is perfectly elastic). The plane of the couple has thus altered its inclination by the angle ϕ; and the couple G has now a component G sin ϕ about the axis of the chuck. It will be observed that G sin ϕ is a torque on the bar, and that there is, in addition to the bending moment, a torque on the specimen of this amount, as well as a bending moment G. But this torque is very small, and it appears that its effect, as far as the fatigue test is concerned, may be neglected. We have then:—Hysteresis work absorbed per revolution—

$$= 2\pi G \sin\phi$$
$$= 2\pi G\phi$$

since ϕ is a very small angle. This work is equal to

the work done on the fibres of the bar during one revolution.

This expression for the work absorbed per revolution remains valid for the usual arrangement of the Wöhler test, wherein one force only is applied at the extremity of the rotating bar. The couple G is then the product of the force so applied and the distance "d" between the line of action of this force and some point on the part of the bar which is held rigidly by the chuck. The angle ϕ is the linear lateral displacement (perpendicular to the plane of the couple) divided by "d."

It is assumed that the force at the extremity of the bar remains parallel to itself, as is the case when the force is a dead weight, or as is sensibly the case when the force is applied by a cord or jointed rod of sufficient length.

Thin-walled hollow Specimen under Uniform Bending Moment.—Considering now a very thin walled hollow specimen to which equal and opposite forces F are plotted as shown in Figs. 2*a* and 2*b*, let $\pm p$ be the limits of variation of direct stress on an element of area subtending an angle δa at the centre of section (*see* Fig. 3). The area of the element is $r\,\delta a\,t$, t being the thickness of wall and r the mean radius of the tube. The maximum force on this area is $p\,r\,\delta a\,t$.

Let Fig. 4 represent the stress-strain cycle for the group of fibres included in the volume bounded by the area $r\,\delta a\,t$ and a length δx parallel to the axis of the bar. Let $\pm k\,\delta x$ be the elongation and contraction corresponding to the width of the hysteresis loop of the fibres of this element. Then the work done on this bundle of fibres during one revolution is represented by the area of the hysteresis loop, and $= (2p\,r\,\delta a\,t) \times (2k\,\delta x) \times c$ where c is a factor depending on the shape of the hysteresis loop.

The work done on a slice of length δx during one revolution is $4p\,r\,2\pi t\,k\,\delta x\,c$. Thus the work on the whole specimen of "effective" length l is—

$$4p\,r\,2\pi t\,k\,l\,c$$

which must be equal to $2\pi G\,\phi$, which is the work done by the motor in turning the bar through l revolution. So that we have—

$$4p\,r\,t\,k\,l\,c = G\,\phi \quad . \quad . \quad . \quad (1)$$

This relation is, of course, applicable either to "elastic" or "plastic" hysteresis of a thin walled tube under uniform bending moment.

Elastic Hysteresis of a Thin Tube under Uniform Bending Moment.—It has been shown by Rowett* that the factor c for steel for elastic hysteresis is independent of the speed of cycle and $= 0{\cdot}506$. With elastic hysteresis only, the usual formula for bending applies, and $p = rM/I$ where M is the bending moment $= G$.

$$I = 2\pi\,r\,t\,\frac{r^2}{2} = \pi\,r^3\,t$$

so that—

$$p = \frac{G}{\pi r^2 t}$$

The above equation (1) becomes—

$$4\,\frac{G}{\pi r^2 t}\,r\,t\,k\,l \times 0{\cdot}506 = G\,\phi$$

$$\phi = \frac{0{\cdot}506 \times 4}{\pi} \cdot \frac{k\,l}{r}$$

Now $k\,l/r$ is the angle of bending in plane of the couple between the tangents at the ends of length l, corresponding to half the cyclical set SS of Fig. 4. Let—

$$\frac{k\,l}{r} = \psi$$

Then—

$$\frac{\phi}{\psi} = \frac{4 \times 0{\cdot}506}{\pi} = 0{\cdot}645$$

Thus ϕ/ψ is constant, and if measurements are taken of delicacy sufficient to determine ϕ (which the writer thinks possible by the use of the mirror) the (angular) width of the hysteresis loop may be found, and the ratio of the hysteresis strain to the total strain obtained.

Elastic Hysteresis of a Solid Specimen under Uniform Bending Moment.—The variation of the hysteresis with the radius through the solid rod is not known. If it is assumed that at a section of the rod the width of the hysteresis loop at radius "r" is proportional to "r_n" and that the stress also varies as "r" then equating the work done on the rod to the work absorbed, the ratio ϕ/ψ again, is equal to $4c/\pi$. If, however, the stress is assumed to vary as "r_n" and if the width of the hysteresis loop in the solid rod is assumed to vary, as Rowett found for fairly thin tubes as the cube of the stress, the result is—

$$\phi = \frac{8}{3} \cdot \frac{c}{\pi}.$$

Elastic Hysteresis of Thin Tube Under Uniformly varying Bending Moment.—Suppose that the part b (Fig. 5) is the hollow tube under test, and that a and c are sensibly rigid; and let the force F be applied to the free extremity A of a.

Assuming that the hysteresis varies as the cube of the stress, it can be shown that—

$$\frac{\phi}{\psi} = \frac{16}{5} \cdot \frac{(a+b)^5 - a^5}{(a-b)^4 - a^4} \cdot \frac{1}{(a+b)}$$

where $\phi_e = \dfrac{\text{lateral deflection of A (perpendicular to F)}}{a+b}$

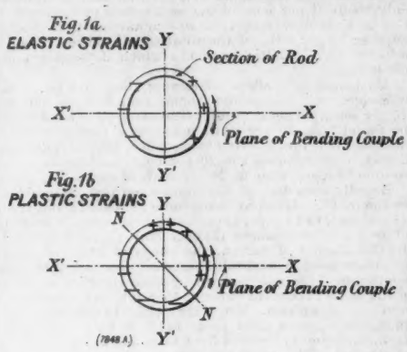
and ψ being, as before, the angle of bending, in plane of F between the tangents at the extremities of b corresponding to half the cyclical set.

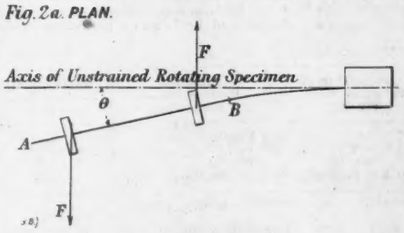
It may be observed that when b is small compared with a, and the bending couple therefore sensibly uniform over b, that

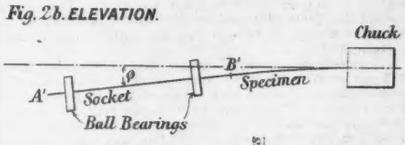
$$\frac{\phi_e}{\psi} = \frac{16}{5} \cdot \frac{5}{4} \cdot \frac{c}{\pi} = \frac{4c}{\pi}$$

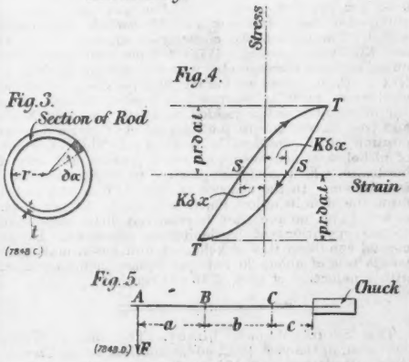
a result which agrees with the result for a thin tube under uniform bending moment.

Plastic Hysteresis on Thin Tube under Uniform Bending Moment.—So far as the writer is aware, the factor c is not accurately known, and indeed, it would seem that c will probably vary with the extent of the hysteresis. Also, the maximum stress p on a fibre cannot be calculated









with accuracy, though the formula which assumes elastic bending is usually employed to calculate p. If this formula be made use of, we have, as before—

$$\phi = \frac{4\,c}{\pi} \cdot \frac{k\,l}{r}$$

and as before, if $k\,l/r = \psi$ = angle of bending between the tangents at the ends of the specimen, corresponding to the half the cyclical permanent set SS of Fig. 4, we have again—

$$\frac{\phi}{\psi} = \frac{4\,c}{\pi}$$

If c is variable, then there is apparently no fixed relation between the angle of lateral bending ϕ and the angle corresponding to the "cyclical permanent set."

If the hysteresis loop (*see* Fig. 4) consists of straight line portions ST, then SS will be the difference between the actual strain and the value the strain would have had at the same stress if the strain had continued to be elastic. This difference may be obtained from the curve of strains plotted against the bending moments G; and this difference, expressed as an angle, will be a near approximation to ψ. The lateral angle ϕ may be observed with sufficiently delicate apparatus. (ϕ has already been used by the writer as a check upon determinations of the elastic limit). With ψ and ϕ thus determined experimentally, the value or values of c may be estimated.

Plastic Hysteresis of Solid Specimen under Uniform Bending Moment.—The distribution of the stress and of the corresponding hysteresis over a section of the rod is unknown. It seems clear that the ratio ϕ/ψ will not have a constant value throughout a Wöhler test. An experimental determination of this ratio on a steel solid specimen gave values varying irregularly between 0·65 and 0·90, ψ being calculated by the method indicated in the preceding paragraph.

* Elastic Hysteresis in Steel. Proc. Roy. Soc. A. 89. 1914.

THE CORRELATION OF THE CHEMICAL CONSTITUTIONS OF "TRUE STEELS" WITH THEIR MICROGRAPHIC STRUCTURES.*

By J. O. ARNOLD, D.Met., F.R.S. (Emeritus Professor and Ex-Dean of the Faculty of Metallurgy in the University of Sheffield).

Introduction.—Before dealing in some detail with the subject specified in the title, it is advisable briefly to answer the question—What are true steels? There are at present known to scientific metallurgy four true steels: (1) True iron steel; (2) true vanadium steel; (3) true tungsten steel; (4) true ferro-molybdenum steel.

General Definition.—True steels may be defined as "saturated steels"—that is to say, steels containing neither structurally free iron nor structurally free metallic carbides.

True Iron Steel.—True iron steel consists entirely of allotrimorphic crystals of the compound micro-constituent "iron pearlite," discovered by the late Dr. H. C. Sorby, F.R.S., about 1863. Pearlite, when properly hardened, is transformed into Sorby's structureless single micro-constituent "iron hardenite," empirically $Fe_{24}C$.† In the early 'sixties the only steel known contained (practically speaking) only the elements iron and carbon; hence Sorby's pioneer discoveries were all made upon this "plain carbon steel." An attempted chemical correlation with Sorby's micrographic work gave only puzzling and unsatisfactory results from a quantitative point of view, and hence he had to make an effort to determine the chemical composition of pearlite by the aid of the microscope alone. This method is now recognised to be quite misleading, and it led Sorby to suggest provisionally that pearlite was built up of alternating layers of a hard carbide of iron alternating with soft pure iron laminæ which were about twice as wide as the carbid striæ. He therefore tentatively concluded that pearlite contained about two-thirds of pure iron mechanically mixed with about one-third of carbide of iron. When Sorby, in 1885 and 1886, read papers on the micrographic analysis of steel before the Iron and Steel Institute, he was obviously unaware of the research work of Sir Frederick Abel, F.R.S., read in 1885 before the Institution of Mechanical Engineers. Abel and Deering had conclusively proved that in "blister steel" containing about 1 per cent. of carbon the latter existed (in the unhardened steel) nearly wholly as the definite compound Fe_3C. Curiously enough, Abel himself was evidently unacquainted with the micrographic work on steel of Dr. Sorby. Unfortunately, this lack of correlation of the work of scientific men working upon the same subject by different methods is still common.

In the early nineties' the author, by strictly correlative researches and by chemical, micrographic and thermal methods, determined the quantitative chemical composition of iron pearlite, proving it to consist constitutionally of a mechanical mixture of alternating striæ of pure iron 86·71 per cent., and carbide of iron (Fe_3C) 13·29 per cent. Empirically this composition corresponds with pure iron, 99·11 per cent. + 0·89 per cent. carbon.‡ The mass microstructure of pure pearlite therefore consists entirely of juxtaposed allotrimorphic (octahedral) crystals, containing, in a state of mechanical mixture with pure iron, about 13·3 per cent. of carbide of iron striæ containing about 6·7 per cent. of carbon. With the above chemical constitution there is always associated 100 per cent. of pearlite or true iron steel, the crystals of which (especially when annealed) present under the microscope (say, at 50 diameters) a beautiful display of colours, the fine carbide striæ acting like an interference grating. Sorby indeed, before using powers sufficiently high to resolve the Fe_3C striæ, deduced their existence from these colours.

Further, in connection with true iron steel (= pearlite 100 per cent.), the author discovered that Osmond's critical thermal points Ac1 and Ar1 coincided with the maximum absorption and evolution of heat respectively on heating and cooling; but that with carbon either above or below 0·89 a diminution of heat was registered, owing to the dilution of the pearlite with structurally free Fe_3C (cementite), or with structurally free iron (ferrite), giving respectively "supersaturated" or "unsaturated" steels. True or saturated iron steel may be conveniently here defined thirdly as a "dyad steel," since it contains only the two elements iron and carbon. Concerning this true steel (and, indeed, the other three steels about to be described) it may be truly said, as the blood is the life, so is the carbon the steel.

True Vanadium Steel.—The general influence of the

* Paper read at the meeting of the Iron and Steel Institute on Thursday, May 10.

† A solid solution of 13·29 per cent. of Fe_3C in 86·71 per cent. of iron, by which pearlite is easily drilled, turned in a lathe, or cut by a chisel. Iron hardenite also scratches quartz.

‡ Proceedings of the Institution of Civil Engineers, December, 1895.

then rare element vanadium on steels was determined by the author in a series of researches made in Sheffield University during the years 1899 to 1902. The discovery of the existence of true vanadium and other true steels was, however, made possible by the development (from 1892 and onwards) by the author and Dr. A. A. Read, Professor of Metallurgy in the University of Wales, of the differential electrolytic method for carbon analysis first used in a crude form by Binks and Weyl for the estimation of carbon in pig-iron. A scale drawing of the apparatus found to be most efficient was published in the Proceedings of the Institution of Mechanical Engineers for March 20, 1914. It consists of two beakers charged with an electrolyte of distilled water and HCl having a specific gravity of 1·02. The polished steel bars, about 3 in. long and ⅛ in. diameter, suspended in the dilute acid to a depth of about 2 in., constituted the anodes, whilst cathodes of platinum plates enclosed in porous cells were employed. The current was from storage cells, and by means of an ammeter and a resistance frame a current density between 0·50 ampere and 0·55 ampere per square millimetre of anode, with a voltage at the terminals between 0·8 and 1·6, was registered during a 12-hour electrolysis of the vanadium steels. These yielded for chemical analysis about ½ gramme of the carbide or mixed carbides. These analyses proved, *inter alia*, that iron containing, say, 0·9 per cent. of carbon and a little over 2·3 per cent. of vanadium yielded a mechanical mixture of the carbides of iron and vanadium with the formula $2Fe_3C + V_4C_3$. When, however, about 4·8 per cent. of vanadium was present, Fe_3C was practically absent, and only the single carbide V_4C_3 was found. It was also established that this result was constant with further additions of vanadium to the steels, at any rate up to 13·5 per cent. vanadium. Hence iron containing, say, 4·75 per cent. vanadium constitutes vanadium pearlite or true vanadium steel, the constitutional formula of which is $Fe_{72} + V_4C_3$. Vanadium pearlite etches dark brown, its carbide being in that very fine state of division which has been called "troostitic," to distinguish it from the laminar carbide of iron pearlite. The latter transforms to its hardenite at 730 deg. C., whereas vanadium pearlite requires a temperature of not less than 1,400 deg. C. to determine the solution of its troostitic carbide in the iron containing it, and the vanadium hardenite when fixed by quenching in cold water micrographically resembles iron hardenite, but is considerably harder, readily scratching topaz, and possibly corundum. True vanadium steel may be chemically distinguished from true iron steel (which is a dyad substance containing only iron and carbon) as a triad steel, consisting of iron, vanadium and carbon.

True Tungsten Steel.—In true tungsten steel there is a displacement point of all Fe_3C when the tungsten reaches a little above 11 per cent. and the carbide (WC) is formed. If a little less than 0·75 per cent. of carbon is present, it is entirely appropriated by the tungsten. Should the added tungsten be well under 11 per cent., the mixed carbides (x $Fe_3C + y$ WC) are obtained. If, on the other hand, the tungsten present distinctly exceeds 11 per cent., a tungstide of iron (Fe_2W) is formed. Tungsten pearlite (Fe_{26} + WC) is a triad substance containing the three elements, iron, tungsten and carbon. Its transformation range seems to begin about 850 deg., and is complete between 1,100 deg. and 1,200 deg. C. The resulting tungsten hardenite corresponds with the formula ($Fe_{26}WC$), which micrographically resembles iron hardenite ($Fe_{24}C$) and readily scratches quartz. To transform completely tungsten hardenite back to its pearlite it requires heating up to a yellow heat (near 1,100 deg. C.), and then to be slowly cooled down overnight to atmospheric temperature. Tungsten pearlite micrographically presents its carbide in a fine state of division (sorbitic), which never laminates like Fe_3C.

True Ferro-Molybdenum Steel.—The critical displacement point for the above triad true steel is at about 18·2 per cent. of molybdenum with, say, about 0·75 per cent. of carbon. Near these critical chemical points Fe_3C vanishes, being entirely replaced by a most remarkable ferro-molybdenum double carbide true steel, which persists up to at least 21 per cent. of molybdenum. Ferro-molybdenum carbide is practically non-magnetic and its formula in its lowest terms corresponds to Fe_3Mo_3C. More probably its formula may be $Fe_6Mo_6C_2$. Its pearlite and hardenite considerably resemble those of tungsten. The formula of ferro-molybdenum pearlite is $Fe_{24} + Fe_3Mo_3C$, and its hardenite corresponds with ($Fe_{24}Fe_3Mo_3C$). The microstructures of both these constituents resemble those of tungsten true steel, with which their hardnesses seem identical. Ferro-molybdenum carbide seems to be chemically the most stable of the carbides of steel, and it is little affected by big differences in the acid strength of the electrolyte employed or by the density of current used for electrolysis.

ADDENDUM.

Elements which Fail to Form True Steels.

Employing up to 24 per cent. of the added elements, the author could find no evidence of the production of true steels by the metals chromium, cobalt, manganese, nor nickel.

Chromium.—No evidence of a true chromium steel was obtained. Chromium steels when electrolysed revealed the presence of Moissan's two carbides, Cr_3C_2 and Cr_4C., and also, when from 15 per cent. to 24 per cent., of chromium was present, a double carbide of the formula ($2Fe_3C$, $3Cr_4C$) was isolated. At about 14 per cent. chromium there was found a critical corrosion point from which (up to 24 per cent. of chromium) the resultant residue was nearly twice that obtained from steels containing about 1 per cent. to 10 per cent. of chromium. During the last few years this 14 per cent. chromium alloy has become familiar in the form of "stainless steel."

Cobalt.—No evidence of a true cobalt steel was obtained from a set of alloys containing from about 2·5 per cent. to 21 per cent. of cobalt and 0·8 per cent. carbon. The dry electrolytic residue (in every experiment) contained only about 5½ per cent. of the total cobalt in the form of Co_3C. Evidence, however, was obtained that about another 5½ per cent. of the total cobalt existed in solid solution as a cobaltic hardenite which decomposed on electrolysis.

Manganese.—In alloys containing about 0·9 per cent. of carbon, with manganese ranging from 0·5 per cent. to 15 per cent., no evidence of a true manganese steel could be found. At 20 per cent. manganese the electrolytic method broke down, owing to secondary internal galvanic action, which caused the 20 per cent. manganese alloy residue to register about 20 per cent. of carbon.

Broadly speaking, as the manganese percentage rose, so the iron displayed by manganese increased; but from 11 per cent. to 13·5 per cent. manganese a double carbide of iron and manganese ($3Fe_3C$, Mn_3C) was registered. In the absence of carbon, the alloys of iron and manganese present remarkable features. For example, iron containing 7·28 per cent. manganese registers a yield-point and a maximum stress of 45·8 tons per square inch and no elongation. An alloy with 13·38 per cent. manganese has a yield point of 23·6 tons per square inch, a maximum stress of 39·1 tons, and 2·5 per cent. of elongation. This alloy has a faint yellow colour. Iron alloyed with 30·6 per cent. manganese has the colour of pale brass, a yield-point of 19·7, and a maximum stress of 41·6 tons. The elongation on 2 in. is 58 per cent., and the reduction of area 65·1 per cent. The above remarkable facts observed by the author and Mr. F. K. Knowles many years ago require careful microscopic correlation.*

Nickel.—From a set of nickel steels containing from 3·3 per cent. to 98·4 per cent. nickel no indication of a true nickel steel was noted. The carbon in these alloys varied from 0·53 per cent. to 0·88 per cent. The commercially pure nickel bar (98·4 per cent. nickel) contained 0·38 per cent. of carbon. Neither was any evidence obtained of the existence of a double carbide of iron and nickel. Throughout the electrolyses mixtures of Fe_3C and Ni_3C were isolated. With 3·3 per cent. nickel the mixed carbides corresponded with the formula ($31Fe_3C + Ni_3C$). From a steel containing 20·3 per cent. nickel the mixture of carbides separated = $Fe_3C + 35Ni_3C$. The bar of metallic nickel yielded no Fe_3C, but only Ni_3C, and free carbon due to the internal electrolytic decomposition of a considerable amount of Ni_3C. Carbide of nickel does not seem to form a pearlite but only a hardenite, which is electro-positive to Fe_3C, depositing free carbon. In the absence of carbon, iron and nickel form the definite alloy Fe_7Ni containing 13 per cent. nickel. This unique alloy is relatively little responsive to the operations of hardening or annealing. In its normal condition this nickelide of iron has a maximum tensile test of about 90 tons per square inch associated with a reduction of area of 46 per cent.

Tabulated Data (Approximate).

Names of True Steels.	Carbon Saturation* Points Per Cent.	Pearlite Formulæ of Saturated Steels.	Compositions of Saturated Steels. Per Cent.	Empirical Compositions of Hardenites.	Displacement Points of Fe_3C. Per Cent.
Iron	0·89	$21Fe + Fe_3C$	Fe 87 + 13	$Fe_{24}C$..	—
Vanadium.. ..	0·83	$72Fe + V_4C_3$	Fe 94·5 + V_4C_3 5·5 ..	Fe 72 V_4C_3	4·8 V
Tungsten	0·72	26Fe + WC	Fe 88 + WC 12	$Fe_{26}WC$	11·3 W
Ferro-molybdenum	0·71	$24Fe + Fe_3Mo_3C$.. ..	Fe 70·5 + Fe_3Mo_3C 29·5	$Fe_{24}Fe_3Mo_3C$ ..	18·3 Mo

* "Eutectoid," as re-named by the late Professor Howe of Columbia University, America.

THE SKODA WORKS, PILSEN.—The Skoda Works delivered, in the year 1922, 40 locomotives to the Czecho-slovak Railroads and 180 to foreign countries. They have repaired 145 locomotives for the railroads of Czecho-slovakia, and 180 for foreign countries. Large orders for railway material have been placed recently with these works by foreign countries. As many as 17,000 employees are now on the pay roll of the works.

* During the discussion of the present author's paper on "The Influence of Carbon on Iron," read in December, 1895 before the Institution of Civil Engineers, Mr. (now Sir Robert) Hadfield called attention to the fact that an iron alloy he had just prepared containing under 0·1 per cent. of carbon and about 3·5 per cent. of manganese was quite soft; whilst an iron alloy with 3·5 per cent. of manganese but 0·54 per cent. of carbon was so hard that it could not be filed or in any way machined. This remarkable discovery was the pioneer observation which led the present author and Mr. Knowles (see Journal of the Iron and Steel Institute, No. I, May, 1906) to reveal, in the crucible steel works of Sheffield University, the astounding properties of practically carbon-free alloys of iron and manganese, a few of which are herein re-described as examples. In fact, Hadfield in 1895 had forecast, in the field of mangano-ferrous research, a discovery which was destined later to establish a metallurgical paradox of astounding importance, the nature of which even to the present day (1923) lacks any satisfactory explanation.

CATALOGUES.

Lock Nuts.—An explanatory pamphlet and list of prices of their lock nuts has been received from Messrs. Vislock, Limited, Salisbury-square, London, E.C. 4. These nuts are stocked in brass for bolts of all diameters, from ¼ in. to 1¼ in., and in steel from ¼ in. to 4 in., larger sizes being made to order. The threads supplied are British standard Whitworth, British standard fine, and Automobile standard up to commonly used diameters, as well as a range of metric sizes.

Plant for Air Treatment.—A complete set of machines for purifying, moistening and cooling air and of instruments for measuring the results of the process are described in a catalogue received from Messrs. Herbert Smethurst and Sons, Limited, Stanley-road, Hollinwood, Lancashire. The system is specially designed for textile factories which present the most difficult problems, but the catalogue is of considerable importance to all interested in the control of air conditions by artificial means.

Truck Crane.—Particulars of a jib crane for attachment to an electric truck are given in a special catalogue issued by Messrs. Ransomes and Rapiers, Limited, 32, Victoria-street, Westminster, London, S.W. The crane platform has two wheels abreast at one end and a pivot support at the other. The pivot connects with the platform of any electric battery truck having four wheels or, when not in use, with a bracket fixed to a wall in the yard. The crane has derricking and hoisting motions and is made to lift 15 cwt. at 12 ft. radius; it can also be supplied for lifts up to 3 tons. An article illustrating and describing the crane will be found on page 331 *ante*.

Engineering Work.—Sweden now includes one of the largest amalgamations of engineering works comprising five large establishments in various parts of the country, with minor branch works, all under the control of Messrs. Nydqvist and Holm, Limited, Stockholm, who have sent us a large folio catalogue of 72 pages containing many impressive views of the works and illustrations of the varied products. The latter include charcoal pig-iron, castings, forgings, tool and structural steel, locomotives, turbines and other prime movers, heavy machine tools, small tools, implements and cutlery, as well as agricultural and manufacturing machinery. This company, we may mention, secured an order for 1,000 goods locomotives from the Russian Government in 1920. A description of the locomotives appeared in our issue of November 18, 1921. The catalogue is well printed in English and very handsomely illustrated.

MARINE STANDARDISATION.—According to *The Iron Age*, a meeting of the Standardisation Committee of the American Marine Association was held recently, when a plan of organisation was adopted. The work of the committee is intended to benefit the marine industries of the United States by establishing recognised standards for hull, engineering and operating details, and thereby reduce the cost of ship construction and operation. This, our American contemporary adds, should make competition with foreign shipping more equal and place the marine field more in line with other branches of engineering effort.

THE CHAMBER OF SHIPPING OF THE UNITED KINGDOM.—The difficult conditions which the British mercantile marine has had, and still has, to meet are clearly explained in "Annual Report of the Chamber of Shipping of the United Kingdom," which has recently been issued for the year 1922–23. In spite of high operating costs, freights have fallen below the level for 1913 in some cases, and in general the earning power of shipping has declined very materially during the last few years. Some economy in working costs has recently been effected by a slight reduction in the wages of officers and men, and it is satisfactory to note that the negotiations to this end have been carried on quite amicably, and the serious consequences of a shipping strike have been averted. Included in the report, which is issued in the form of a bound volume containing 266 pages, are a number of statistical tables and diagrams relating to shipping and commercial matters, and these will be of great interest and value not only to persons connected with shipping, but to all those who have the welfare of the industry at heart.

THE FIAT ELEVATED MOTOR CAR TRACK.—The Fiat Motor Car Company have built on the top of their large factories at Lingotto, in the suburbs of Turin, a track 78 ft. in width and about three-quarters of a mile round, for testing their motor car chassis. The track consists of two straight stretches united by banked curves 20 ft. high; it is throughout of reinforced concrete, covered with asphalt. A thick concrete wall, 5 ft. high, is built on each side of the two straight stretches and on the inside of the curves, there being a wall about 10 ft. high on the outside of the banking. Under the banking are workshops in which the chassis undergoing tests can be adjusted; a direct entrance to these workshops is provided at the end and side of the straight stretch, and cars can enter and leave the workshops to enter the track again without interfering with those being run at high speeds on the track. The straight stretches are slightly cambered to allow the water to run away on each side. The hot water heating piping in the factories underneath the track will melt any snow which may fall on the track. Communication between the track and the factories underneath is insured by 17 electric lifts. The track is about 100 ft. above the ground level.